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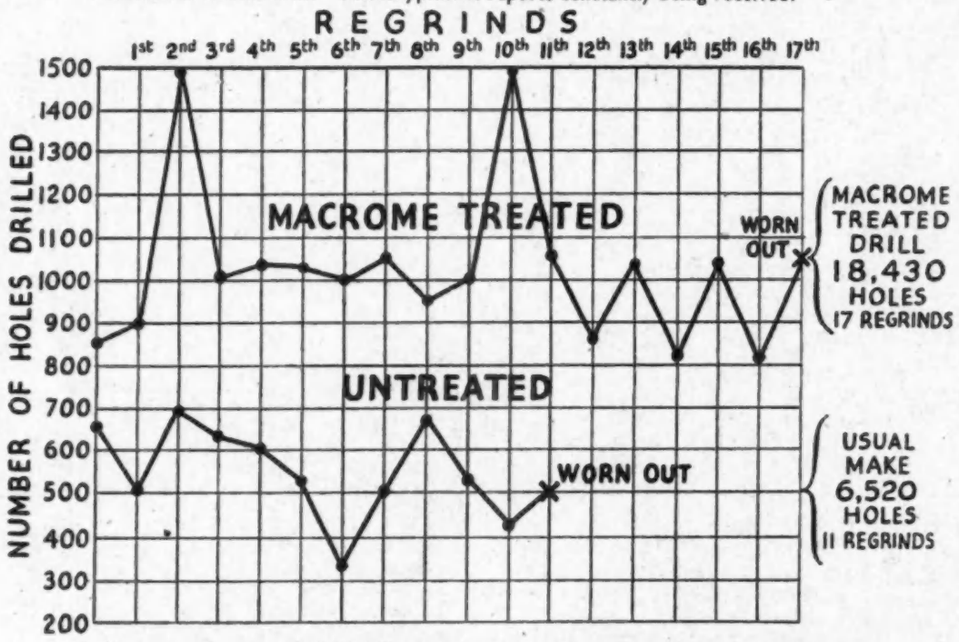
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ENGINEERING.

DAM CONSTRUCTION IN THE TENNESSEE VALLEY.

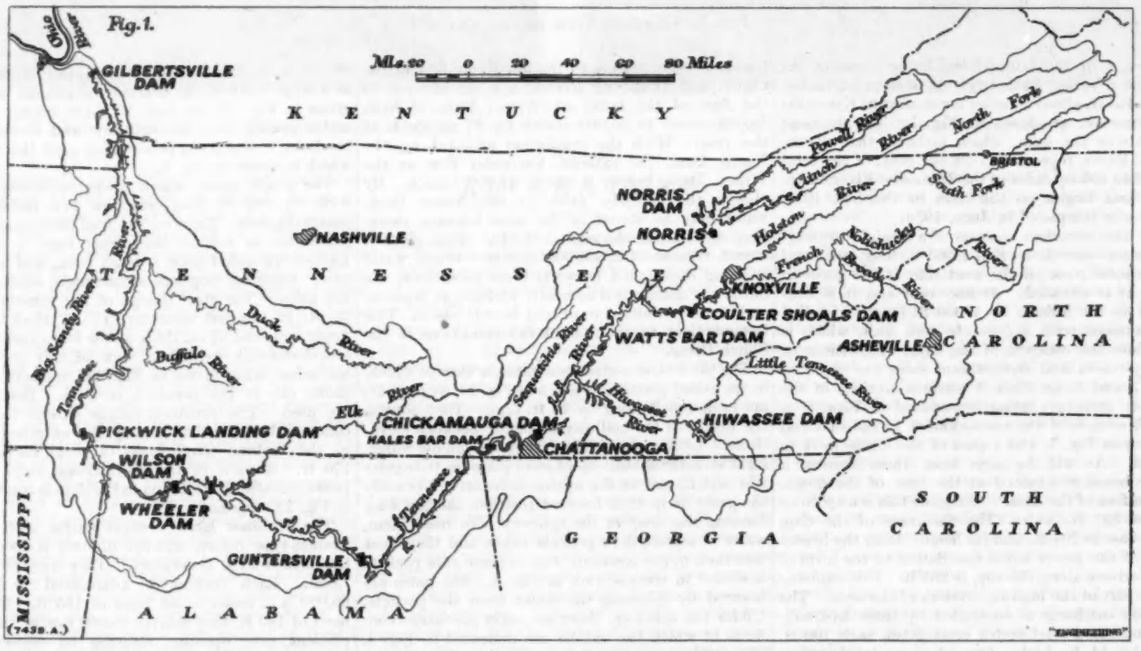
REFERENCE has been made from time to time in these columns to the Mississippi River system, in the south-eastern part of the United States, and to the large-scale works which have been undertaken in the lower reaches with a view to alleviating the effects of the devasting floods which have frequently occurred.* Mention has also been made of the controversy on the subject of the possible effects, on the lower river floods, of the construction of storage reservoirs in the upper reaches of important tributary streams.† In this connection, it is of interest to note that in House Document No. 1 of the 74th United States Congress, the President of the Mississippi River Commission is quoted as stating that "This Commission has recently submitted a separate report on a comprehensive system of tributary reservoirs for control of floods in the lower Mississippi River. In this report it was shown that, in connection with the existing levee system, substantially complete protection, except for backwater areas, might be obtained by such a tributary reservoir system."

Among the tributaries of the Mississippi, the Tennessee River occupies an important place. Rising in the Clinch Mountains and flowing through Tennessee and northern Alabama, it joins the Ohio River at Paducah, in Kentucky, some 50 miles above Cairo, where the Ohio flows into the Mississippi. The whole of the Tennessee River, from its source to a point near Paducah, is controlled by the Tennessee Valley Authority. Flood control was only one of the objectives of the Tennessee Valley Act of 1933, which created this Authority. As is well known, it is also engaged in electric power production on a large scale and in the manufacture of nitrates at Muscle Shoals. Its various activities have been the subject of much controversy in the United States. With this matter we are not now concerned; our present purpose is to deal with some of the large dams which have been constructed by the Authority. Work of this kind has been of an extensive nature, as a result not only of the growing realisation of the importance of flood control, but also because of President Roosevelt's policy of favouring large-scale power and irrigation projects, with the idea of absorbing unemployed labour to a great extent.

The map of the Tennessee Valley Authority's area, reproduced in Fig. 1, on this page, shows the various dams which have been built, or are being built, on the river and its tributaries. Some of these, notably the Wilson Dam at Muscle Shoals, we have already dealt with.* In this series of articles, we propose to describe in some detail the constructional and other engineering features of the Norris, Wheeler and Pickwick Landing Dams, dealing in the first instance with the Norris Dam, which lies nearest to the source of the river. The importance of these structures from the point of view of flood control was emphasised some time ago in a statement, by the chairman of the Authority, to the effect that although there were heavy rains in the Tennessee River drainage basin, and a record flood on the Ohio River, in the winter of 1936-37, yet no serious flood occurred on the Tennessee during that period. Potentially, the Tennessee River is an important waterway for navigation, and the control which is given by the construction of dams is also of benefit in connection with navigation of the Ohio and Mississippi Rivers. By the working out of what is considered to be the best economic compromise, the works which are being carried out on the Tennessee River serve the three purposes of aiding navigation, flood control and the generation of electricity. An incidental result of the creation of a number of large reservoirs has been the development of the Great Smoky Mountains National Park, one of the great recreational areas of the United States.

The construction of the Norris Dam was definitely

Fig. 1.



* See ENGINEERING, vol. 143, pages 182 and 213 (1937).

† See ENGINEERING, vol. 136, page 82 (1933).

* See ENGINEERING, vol. 126, page 151 (1928).

NORRIS DAM ON THE CLINCH RIVER, TENNESSEE, U.S.A.

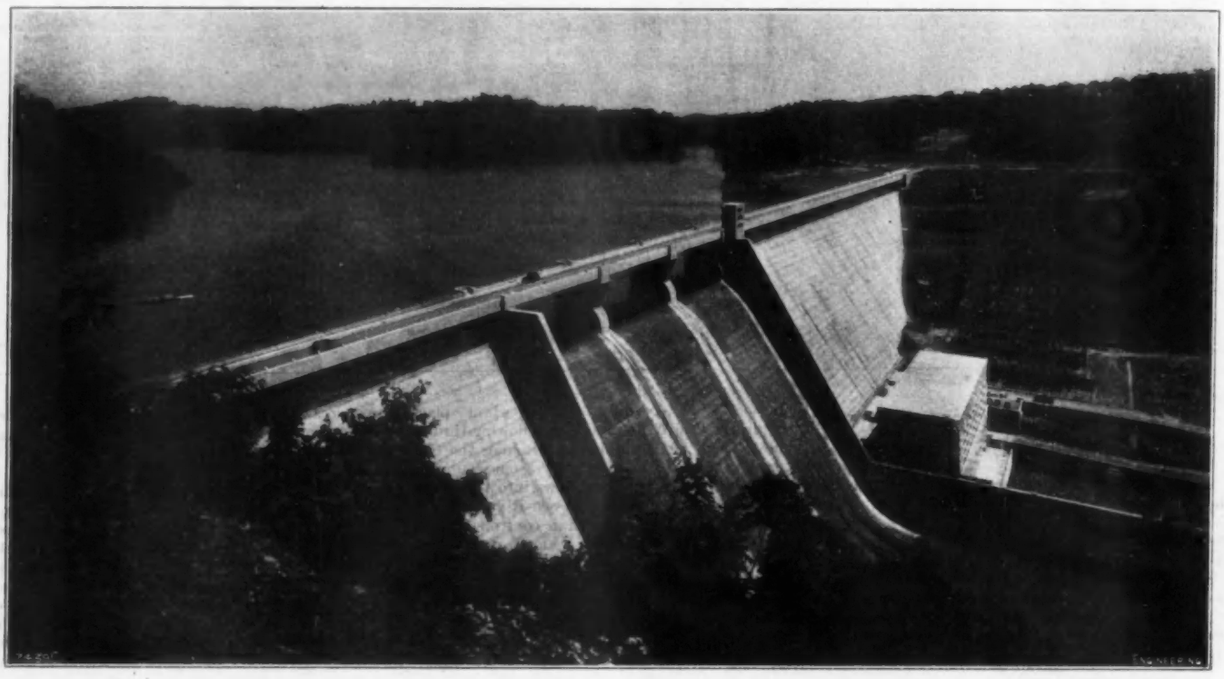


FIG. 2. GENERAL VIEW OF COMPLETED DAM.

authorised in the original legislation creating the Tennessee Valley Authority. It is situated on the Clinch River, about 20 miles north-west of Knoxville in Tennessee, as shown in Fig. 1. The drainage area above the dam, which includes that of the Powell River, represents 7·26 per cent. of the total area of 40,600 sq. miles of the Tennessee River basin. Work was begun on the dam in October, 1933, and it was completed in June, 1936.

The dam structure consists of a straight gravity-type mass-concrete section 1,560 ft. long, anchored to the solid rock on the west side of the gorge in which it is situated. At the east end it is connected to the hillside by a 300-ft. length of rolled embankment with a concrete core wall, which is built into the concrete of the dam. Elevations of the upstream and downstream sides are given in Figs. 3 and 4, on Plate I, various sections of the concrete structure being reproduced in Figs. 6 to 10. A section of the embankment to the east end is given in Fig. 7, and a plan of the whole work in Fig. 5. As will be seen from these figures, a power house is situated at the base of the downstream face of the dam. Alongside this is a spillway section 332 ft. wide. The thickness of the dam at its base is 204 ft. and its height, from the lowest point of the power-house foundation to the level of the roadway along the top, is 265 ft. This roadway forms part of the highway system of the area. The spillway discharge is controlled by three hydraulically-operated steel sector crest gates, each 100 ft. long by 14 ft. high. One of them is shown in cross-section in Fig. 8. The gate openings are spanned by a concrete-encased steel-girder roadway bridge. This is shown in Figs. 3 and 4 and is clearly to be seen in the general view of the completed dam which is given in Fig. 2, on this page.

The normal impounded level of the reservoir above the dam is to elevation +1,020, the crest of the spillway. This is also the level to which the water is allowed to rise for power storage, and gives a gross head of 194 ft. The volume of the reservoir above the dam between elevation +1,020 and elevation +962, 58 ft. below, is 1,500,000 acre-ft., this being the amount of water available for regulation of the power output and for navigation. This storage allows for an average contribution of 5,000 cusecs to the low-water flow of the Clinch and Tennessee Rivers, and an increase in the flow of the latter at Wilson Dam of from 10,000 cusecs to 16,000 cusecs for 97 per cent. of the year. With the regulation afforded by the Norris Dam, the extreme low-water flow at the Wilson Dam, below, is about 12,900 cusecs. By closing the spillway gates of the Norris Dam, water may be stored in the zone between elevation +962 and elevation +1,047. This gives a stored volume of 2,500,000 acre-ft. When water is being impounded between these elevations, the outflow is maintained as nearly uniform as possible, and is not permitted to exceed 30,000 cusecs. This is equivalent to about bank-full conditions in the Clinch River.

The three steel sector crest gates, a view of which, in the raised position, is given in Fig. 15, on page 10, are each 100 ft. long by 14 ft. high. They control the height of the spillway discharge between elevations +1,020 and +1,034. They are hollow water-tight structures built up of steel plate on triangular ribs and hinged at the upstream corner. Normally the gates lie in their lowered position, the top sides forming the crest of the spillway. To raise them, water is admitted to pockets below and they float into their upper position. One of these gate pockets is shown in cross-section in Fig. 8. The gates are lowered by releasing the water from the pockets. Under the spillway, there are eight discharge conduits of which the outlets are indicated in Fig. 4. The conduits are 5 ft. 8 in. wide by 10 ft. high, and are laid out on trajectories with their entrance sills at elevation +860. Each is equipped with two sliding gates, one behind the other, as shown in the cross-section, Fig. 8. These are operated by 24-in. diameter pressure-oil cylinders. Normally one sliding gate only is employed, the second acting as an emergency stand-by. The first 48 ft. of each conduit is provided with a cast-iron liner, as indicated in Fig. 8. Immediately below each of the two sliding gates there is a 12-in. air-vent pipe. The conduits have a total discharge capacity of 37,000 cusecs. Trash racks are provided at the conduit entrances, as shown in Figs. 3 and 8. As will be clear from the former figure, there are four racks for the eight conduits. They are well shown in the view of the upstream face of the dam, at a stage when it was nearing completion, which is given in Fig. 16, on page 10. The energy of the water passing over the spillway, and through the conduits, is dissipated in a stilling pool, the form of which is shown in Fig. 8.

The power house, which is approximately 70 ft. wide by 204 ft. long, contains two 56,000-kVA generating sets. These are supplied through separate penstocks, as will be clear from Figs. 5 and 10. Each is provided with a trash rack, and a roller gate. Seats for stop-logs are arranged upstream of the gates. The steel linings of the penstocks are 20 ft. in internal diameter, $1\frac{1}{2}$ in. thick at the upper end, and $1\frac{3}{4}$ in. thick at the lower end. They are electrically welded, a view of this process in operation being given in Fig. 11, opposite, which shows one of the penstock sections. Butt joints are used. The penstock linings extend from the concrete bell-mouths, behind the entrance gates, to the turbine scroll cases, a total distance of 176 ft. A view of the downstream ends of the penstocks after installation in the dam is reproduced in Fig. 12, opposite.

The turbines have vertical shafts with single Francis-type rotors, and are directly connected to the 56,000-kVA generators. They run at 112·5 r.p.m. Each turbine is guaranteed to deliver 66,000 h.p. under a net head of 165 ft. Under a head of 180 ft. they deliver 60,000 h.p. at the most efficient gate opening, showing an efficiency of 91 per cent. The scroll cases are of riveted steel plate construction, 20 ft. in diameter at the inlet end. An interior view of one of the cases is given in Fig. 13, on page 4. The speed rings are made in four pieces, each section with three vanes cast integrally. The lower part extends downwards to form a foundation ring. The rotors are 14 ft. 6 in. in diameter and 6 ft. 10 in. high. They are single-piece steel castings, each weighing 45 tons. Each is designed to carry its own weight, in addition to that of the shaft, when disconnected from the generator and resting on the speed ring. The turbines were constructed by the Newport News Shipbuilding and Dry Dock Company.

The generators, supplied by Messrs. The Westinghouse Electric and Manufacturing Company, are

NORRIS DAM ON THE CLINCH RIVER, TENNESSEE, U.S.A.

FIG. 11. SECTION OF PENSTOCK BEING WELDED.

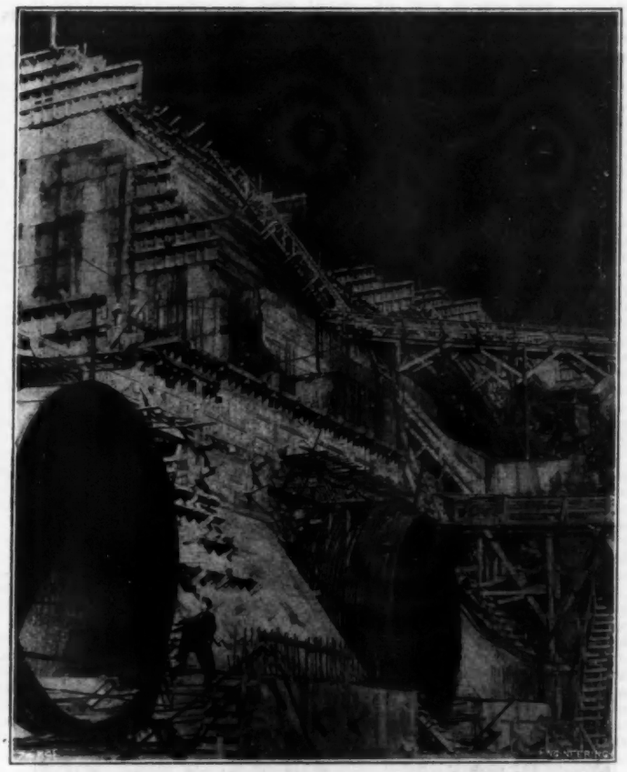


FIG. 12. DOWNSTREAM ENDS OF PENSTOCKS.

of the umbrella type with a single combined thrust and guide bearing located immediately below the rotor. They are rated at 56,000 kVA at 90 per cent. power factor. They generate 13,800 volt, 60-cycle, three-phase current, the guaranteed efficiency at full load being 97 per cent. The machines are 41 ft. in overall diameter. The rotors weigh 250 tons each and are 27 ft. 6 in. in diameter. A view of the interior of the power house, showing one of the rotors being lowered into place, is given in Fig. 14, on page 4. The main exciter armature is carried by a spider mounted on the main rotor and the pilot exciter armature is located inside the main-exciter rotor, the field frames being carried by a bracket at the top of the main machine. The adoption of this arrangement has reduced the overall height by 3 ft. 6 in. The generators are supplied with closed air circuits, the heated air passing over water-cooled radiators. The housings are practically air-tight, so that, in emergency, CO_2 fire-extinguishing equipment may be employed.

The machines are directly connected to banks of transformers, synchronisation being effected on the high-tension side. The transformers are in the open, in an outdoor switch yard located on the hill side to the east of the power station. It can be seen in Fig. 2. Each machine is connected to a bank of three 18,667-kVA transformers connected in delta-star. They step up from 13,200 volts to 154,000 volts. Taps are provided by which 110,000-volt current may also be obtained. There are also two 750-kVA, 13,200-volt to 480-volt service transformers connected directly to the generator leads. Each generator and transformer group has differential relay protection. Operation of the relay disconnects the machine and transformers from the high-tension 'bus bars, opens the exciter circuit, energises the governor shut-down solenoid and applies the generator brake. This brake can stop the machine in 15 minutes.

(To be continued.)

LITERATURE.

Mathematical Methods in Engineering. An Introduction to the Mathematical Treatment of Engineering Problems. By DR. T. VON KÁRMÁN and PROFESSOR M. A. BIOT. London: McGraw-Hill Publishing Company, Limited. [Price 26*s.*]

INTRICATE dynamical and electrical phenomena have at all times attracted the attention of the physical investigator, and the related theory is a wide field, well and fruitfully cultivated by the mathematician. The achievements of pure science and of analytical method in this line are quite remarkable; but in the past the engineer has only had a casual interest therein, the simplest elements of the subject serving his purposes. Within comparatively recent times, however, he has been compelled to change that attitude. The extraordinary advances in the design and construction of modern machinery and structures have brought in their train a somewhat confused, but certainly important, series of questions in mechanical and electrical science. The rise of such problems as are connoted by the design of continuous frameworks, the buckling of a rectangular lattice truss, the stability of aeroplanes, and the frequencies of electric-wave filters, have taxed severely—and in some directions, overtaxed—both engineering technique and analytical resource. This sphere of scientific research has been reasonably examined under the combined impetus of serious failures, elaborate investigation, and the resources of high theory.

The rate of progress has been rapid, and it is not surprising that authoritative treatises on the application of advanced mathematics to such problems are mainly conspicuous by their absence. A warm welcome is to be extended, therefore, to the present attempt to fill the gap, especially when one of the authors is so able a writer on analytical subjects as Dr. Theodore von Kármán, well known as the director of the Guggenheim Aeronautics Laboratory in the California Institute of Technology.

The first two chapters deal with ordinary differential equations and Bessel functions. The theoretical work here discloses aspects of fundamental importance in mathematics. It is applied to several questions of special interest to engineers, as is shown by the examples relating to the transmission of heat, and the theory of lubrication and of plasticity. The next two chapters deal with matters more familiar to the same class of reader. In them, the principal concepts of dynamics are discussed and exemplified with the help of vectorial algebra and Legrange's equation of motion. It is hardly possible to over-estimate the practical value of these analytical instruments of investigation in the study of small installations of both conservative and non-conservative systems, to which Chapters V and VI are devoted. They contain an instructive comparison between mechanical and electrical oscillations, and precede well-arranged chapters on the differential equations of the theory of structure, and the application of Fourier series to structural problems.

In the final part of the work the authors present chapters entitled "Complex Representation," "The Operational Calculus," and "The Calculus of Finite Differences." A practical significance attaches to the subsequent applications, which include rules for the calculation of the impedance of electrical systems, for the response of electrical networks to prescribed voltages, and for the voltage drop in a string of electrical insulators.

The authors' scholarship is profound, and the book, in addition to its own wide scope, provides numerous references to supplementary sources of information. In the development of the subject-matter, examples and diagrams are aptly used and

NORRIS DAM ON THE CLINCH RIVER, TENNESSEE, U.S.A.

(*For Description, see page* 1.)

FIG. 13. INTERIOR OF TURBINE SCROLL CASING.

FIG. 14. GENERATOR BEING ASSEMBLED IN POWER HOUSE.

carefully embodied in the text. The volume may be highly recommended to the serious student of physics in general, and of engineering in particular.

Water Treatment. By G. V. JAMES, M.Sc., F.I.C. London: The Technical Press, Limited. [Price 30*s.* net.]

CONSIDERABLE attention has been given to the technical aspects of water treatment during recent years. The water used for industrial purposes is of widely varying degrees of hardness and purity, and the treatment applied depends largely on the purpose for which the water is required to be used. The ideal boiler-feed water is seldom obtainable from any natural source, and most of it requires treatment if steam raising units are to be maintained in good condition. Modern developments and social conditions have given rise to many problems of water purification, and ingenious processes have been devised for the provision of potable water supplies for military purposes and for use in sea-going vessels. Methods of treatment to prevent growths of algæ in water have found many practical applications; whenever water is exposed to air and sunshine, algæ will gain entry and often will develop profusely unless inhibited. This inhibition adds to the cost of water purification and although it is possible to do much in the way of prevention, no completely satisfactory solution has yet been attained. These and many associated subjects are discussed in the volume under review, which consists mainly of a compilation of previously published matter on water treatment.

Various physical and chemical sterilisation methods are dealt with, as also are processes used for the purification of water for swimming baths, and to prevent plumbo-solvent action. Reference is made to the prevention of contamination of water by toxic gases, and the effects of contamination due to effluents, and there is a short section dealing with domestic sewage. The scope of the book is fairly wide, as will be clear; but in view of the fact that so much of the material is already available elsewhere, the price must be regarded as high for a volume of its comparatively modest dimensions.

Procedure Handbook of Arc Welding Design and Practice. Sixth edition. Cleveland, Ohio: The Lincoln Electric Company. [Price in Great Britain, 9*s.* 6*d.*]

THAT six editions should have been required of a book which first appeared as recently as 1933 is, in itself, evidence of the rapid extension of welding practice. The *Lincoln Handbook* is based on American practice and the direct-current system of welding, this being favoured by the manufacturing policy of the company. The requirements and characteristics of these machines are dealt with at length, but there is also much valuable information which applies to, or can be adapted for, alternating-current systems. All costs are expressed in American units, but the many cost tables are still valuable for comparison, and the method of analysis is open to all. The early part of the book deals with the general procedure of welding, definitions of terms, stress relief, visual inspection and tests. The description of the American system of notation giving welding directions for works guidance is interesting; a standardised system, conveying to the works concise, but complete, information as to the welding required by the design, is something to be sought after. This system certainly fulfils that purpose but it looks very complicated, and to make it universally understood in the works would be a slow process. Part 3, dealing more particularly with the welding of mild steel, contains an extensive collection of tables giving times, speeds and costs for all the usual types of joints, ranging from heavy plate to sheet metal, and even plug welds. Notes on carbon-arc welding are included, more notice being taken of the use of bare-wire electrodes than might be thought necessary. Similar, but less extensive, tables deal with the welding of cast iron and various alloys. In general, the physical properties of the metals are considered first, thus leading to the requirements of welding technique, and to electrodes.

The latter half of the book is devoted to design for arc welding. The section dealing with machine design pays considerable attention to costs, comparing the costs of different methods of achieving a particular result. The relation between forming costs and welding costs may differ in this country sufficiently to make designers prefer more welding and less forming than is advocated by the authors, and some of the comparisons made certainly would not hold on this side. The method of approach is sound, however, and the whole chapter is worth careful study. The chapter on arc-welded structures assumes a good knowledge of the theory and practice of structural design, which is adapted to incorporate in the basic outlines of a scheme, as well as in the details, such advantages as may be gained by welded connections; for roof structures, for example, rigid welded connections are employed to give increased head room by avoiding cross ties. A series of formulæ are worked out for some standard types, to simplify the complicated calculation which results when joints are taken as rigid instead of the usually assumed pin joint.

The standard of this work is such that, sooner or later, a new edition is sure to be required. It would be helpful if the fatigue value of welded joints could then receive more attention. Figures for this factor, given after recent researches in this country, seem to be considerably less than those given by the authors. Some recent papers, too, do not support their view that overhead welding can be reckoned to be as strong as the normal down-hand welding.

THE ENGINEER IN WAR-TIME.*

By THE RT. HON. THE VISCOUNT FALMOUTH.

I DO not suppose that there has ever been a period before in which the engineer, and especially the young engineer, has been called on to assume so heavy a burden of responsibility. In the three great fighting Services, technical requirements are in urgent and universal demand, and there is an immense field open to him to serve his country. There is a great demand, too, on the supply industries to increase their output to meet the requirements of the Services. Here the work of the engineer is one of the most important factors in the situation. But not only in the Services and in the matter of supply must the engineer play his part. His help is vital if we are to maintain those essential services of the country which to-day are the target of the enemy's bombing attacks. Transport, electricity, gas, water—all are necessary to the nation's power to carry on, and indeed to its very existence. Their repair and maintenance are the province of the engineer, and the measure in which they, to-day, are running after weeks of *Blitzkrieg* is the best tribute to the wonderful work which engineers are doing.

It is nothing novel to find the science and art of the engineer called in to supplement the science and art of the warrior. All through the ages the engineer has had intimate connection with the fighting man, and the inventions and developments which he has made, mainly in the arts of peace, have always been called on in the greatest of human emergencies—the time of war. Long before the profession of engineering was recognised as such, the predecessors of the engineer—the smith, the mason, and the carpenter—were called upon to help the soldier. If ever there was an engineering job, it was the construction of the wooden horse of Troy. Even more ambitious, but not so fortunate, was the building by Xerxes' engineers of a bridge of boats to carry his army across the Hellespont to invade Greece. Strange what difficulties a narrow strip of water has time and again presented to the plans of dictators. Later came the problem of how to destroy your enemy at a greater distance than the length or throw of the human arm; and this has produced a bewildering variety of engineering devices, and all the kindred problems of supply and maintenance.

A strange feature, however, is the slowness with which military engineering has progressed. The invention of gunpowder was one of the fundamental occurrences in the history of war. Its potentialities and implications were enormous; yet it was not for hundreds of years that any great advance in the technique of its use took place. The guns that beat the Spanish Armada were very similar to those which, two hundred years later, settled the question of sea power at Trafalgar. Indeed, the very ships which fought under Nelson might have been worked with very little extra training by Drake and Hawkins. It has almost always been in peace that the new developments have first taken place, and progress, even in weapons of war, come mainly by application for military purposes of the arts of peace.

It is the fashion in some quarters to-day to lay all the ills which have befallen mankind in these last years at the door of the scientist and the engineer; but that is not the truth. It is not the mechanical apparatus which is wicked, or even the man who invented it. The product of the engineer, as such, is neither moral nor immoral—it is rather amoral, and all the responsibility rests on him who uses that product for good or ill. One of the most glaring examples of this perversion is the use made of the internal-combustion engine. On a bright moonlight night, as the bombers rain down death on all and sundry, one thinks, not without some reason, that the internal-combustion engine is one of the most devastating disasters which have ever fallen on man. But the internal-combustion engine was not invented for this—it was invented and developed for purely peaceful uses, and the tragic sequel could not possibly have been foreseen. The plain fact is that man's discoveries and material progress have outrun his moral growth, and till he grows up a bit and learns better ways, he will be a danger to himself and all around him; but that is the world in which we find ourselves, and we have got, as engineers, to consider how we can best promote what we believe to be a good cause, and one which, if successful, will make for a better world. The first thing we have to consider is the relative importance, in time of war, of many things which in peace we have taken as foregone conclusions.

A nation at war requires at once a mass of engineering products of all kinds, and there is a huge demand for mass production of articles which in peace we do not need at all. Organised as we are in this country, delays and disappointments are inevitable, and there is only one way in which they could be avoided—if, in peace, large and regular sums of money are set aside for research and development of war material, and in the design and production of special tools and processes suitable for the turning out of this material in great quantity at the outbreak of war. This is not militarism; it is plain common sense. It is not producing large stocks of war-like material, which might alarm other nations and drive them into an arms race. It is merely making it possible, should we be attacked—as we have been twice in one generation—to manufacture quickly the munitions we should require.

We have the example of the last Great War to guide us. In 1914 we were shockingly unprepared in every field. We were short or deficient in almost everything you like to mention—many of the munitions we needed could not be made in this country. We were even told officially that the very periscopes for our submarines were made in Germany. The result is well remembered by the older ones of us here to-day—delays, shortages, disasters, and terrible waste of lives. We are now apt, some of us, to blame successive governments of the past twenty years, and to say that they should have prepared more vigorously; but if we are honest with ourselves, we know that the blame lies on the shoulders of everyone of us, young and old alike. We hated war, and loathed the very idea of it, and any suggested increase in expenditure on armaments was viewed with disfavour by the nation as a whole.

Engineers know, far more than the man in the street, how vital is research. It is not too much to say that the whole future of an industry like ours depends on wise and adequate research. We must do all in our power to instruct and persuade the country that research must go on, in every field, in peace as well as in war. The country must learn from the bitter lessons of the past, and see to it that never again is the research of the three fighting Services starved for want of funds.

As I have said, war presents many new problems to the engineer, and almost establishes a new set of values. The demand for huge quantities of the same article brings about almost the ideal conditions for mass production, but this demand bears little or no resemblance to the production of munitions in a peace-time world. Then, manufacturing problems such as are met with in war only arise to a minor degree. In consequence, designs tend to be adopted which do not appear to bear any resemblance to the possibility of reproducing them in great quantities at a high rate of output. This tendency may be valuable, in that it keeps up a high standard of quality, but, in war, quantity and speed of output are of overwhelming importance, and not a single man-hour more than is absolutely necessary should be spent on any job. It follows, therefore, that all designs should be as simple as is consistent with efficiency. Those curves which "make a job look nice" must be ruthlessly eliminated. "Limits" and "clearances" should be as great as possible. The theory that weapons should be given a superfine finish may possibly arise from the peace-time custom of the Services to devote hours to "spit and polish." Whether this is, or is not, the best method of utilising a man's time, I do not pretend to say, but superfine finish is often a dangerous snare in war, and the rule should be "just as high a finish as is absolutely necessary to secure efficiency, and not a scrap more."

To-day, engineering firms are being called upon to undertake war work of every kind—work in which they usually have had no previous experience. It is most important, therefore, that the designs given out to these firms should be of as straightforward a character as can be, so that they can be turned out on the class of machine tool which is to be found in the average machine shop. The need for special tools should be avoided, whenever it can be, to avoid delay. This desirable state of affairs cannot always be said to have prevailed, though great improvements have taken place in recent times. In normal times, there is always a tendency on the part of the Services to aim at a 100-per cent. solution of a given problem. Now the engineer knows that—while it may be comparatively easy to attain, say, an 85-per cent. solution, the difficulty of that "something extra" is great, and long delay, running perhaps into months, may ensue before success is achieved. Indeed, it would sometimes appear better to be content with the 85 per cent. now, rather than wait for a better result later. Weeks and months in war have a habit of being decisive.

There is another factor, too, which makes war work difficult. In war, secrecy is a matter of the utmost importance. This is obvious for many reasons, but what is not always so clear is that secrecy often hampers production. This was even the case in peace time, when firms were often asked to produce a given article, but were not told the full story, with the result that mistakes and delays occurred which need not have taken place if the firm had been taken into full confidence by the Service concerned. Though it is not primarily a question for the engineer, the proper adjustment of the claims of secrecy and speedy production is a most delicate and important one.

One peculiar feature of this war from the engineer's point of view is the enormous development of what we may call the "gadget." The war might quite truly be named a gadget war, so much of our time is spent on these things. As guns become more accurate, as 'planes fly faster, and as ships move more swiftly, so the instruments of precision which are needed in order to get the maximum benefit from these things become more elaborate. If gadgets by the thousand were called for in the last war, they are numbered by the tens of thousands in this. The watchwords for engineers to-day are elasticity of thought, adaptability of mind, readiness to alter preconceived ideas when necessary, and willingness to improvise with new methods, new tools, and strange materials. We have much to learn from our enemies in their ways of dealing with "*ersatz*" conditions.

But, when victory is achieved, we shall not be able to sit back and pause. A heavy weight of responsibility will still sit on the shoulders of the engineer, for, though the planning of reconstruction may lie in other hands, the methods and actual work of restoring a stricken world will fall largely to the scientist and the engineer. When the Napoleonic wars left England and Europe in a state of profound exhaustion, it must have seemed impossible that recovery could take place for a long time; but depression lifted gradually, first in this country and later in Europe, largely due to James Watt and the development of his steam engine. A new source of power was made available to industry at a reasonable cost, and the prosperity of the Nineteenth Century became an accomplished fact.

After 1918, England was again exhausted by the immensity of her effort, but, though we had several severe economic storms to weather, on the whole our recovery was fairly rapid, considering the sacrifices we had made. This time we have not had an entirely new prime mover to come to our assistance, as we had in 1815, yet the years 1918-30 saw the large steam turbine reach a high state of efficiency and reliability, and it was possible to supply power at very cheap rates. This, no doubt, contributed largely to the national recovery. The fact that power from a thermal unit could be sold as cheaply as power from a hydro-electric station enabled this country, with its small water-power resources, still to compete with countries more favourably placed in this respect. To-day, we ask ourselves if there is any form of prime mover which is likely to do for our generation what the Watt engine did for the years after 1815, and the Parsons steam turbine did for 1918 onwards? And the answer is difficult to come by.

The high-compression internal-combustion engine, using either oil or gas, may be an answer. It has a high thermal efficiency, and has now arrived at a state of great reliability. The fact that it can operate on either of these fuels, without even changing the compression ratio, gives it an important flexibility. An engine running on coal gas has this great advantage to us, provided it can be made highly efficient and reliable; it is using home-produced fuel, and this coal, during the process of gasification, is capable of yielding many valuable by-products. In the marine field, as far as coasting vessels are concerned, we may see the development of a high-compression two-fuel engine, running on suction gas in the open sea, and turning over to oil when it reaches narrow waters. The internal-combustion turbine, too, presents possibilities which are still being explored. Besides the assistance given to the world by the supply of cheap power in huge quantities after the last war, the years since have seen a great development in methods of manufacture; improved methods which would not have seemed possible a few years ago. Developments, too, of new ferrous and non-ferrous alloys, and the rise of the plastics industry, give much grounds for hope.

One lesson we must learn from this war—a thing which has disheartened many engineers before the war—was the number of high-grade machine tools which were imported from Germany and elsewhere. We were just as capable of producing these as the foreigner, but for some reason this very important field, with one or two notable exceptions, was sadly neglected. The reasons were not necessarily technical—indeed, they were more in the economic field—but the high reputation we now have for very elaborate products, such as aero engines, should leave no one in doubt in the future that we can turn out small-grade machine tools of an excellent quality. But all these things are for you to deal with in the future. Now, we must leave the engineer carrying on the vital task of designing, building and operating the immensely complicated machine which we call mechanised war. On the success of that machine depends our very existence, and the happiness of the world in the coming years. When victory is accomplished, we shall still look to the engineer to take his part in establishing and reconstructing the future of the world. Our engineers have led the world, time and again, in inventiveness, in courage, and in resource, and what they have done in the past I believe they can, and will, do in the time to come.

* Presidential address to the Junior Institution of Engineers, delivered in London on Saturday, December 14, 1940. Abridged.

ROTARY-VANE LIGHT-WEIGHT VACUUM PUMP.

MESSRS. FENTON-SMITH BROTHERS, WALTON-ON-THAMES.

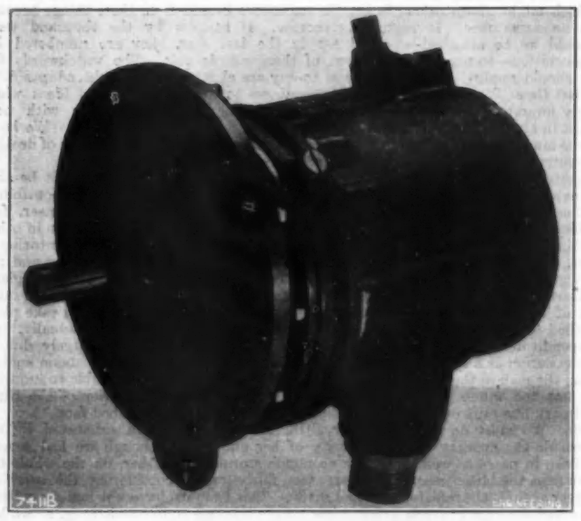


FIG. 1. PUMP WITH SIDE INLETS.

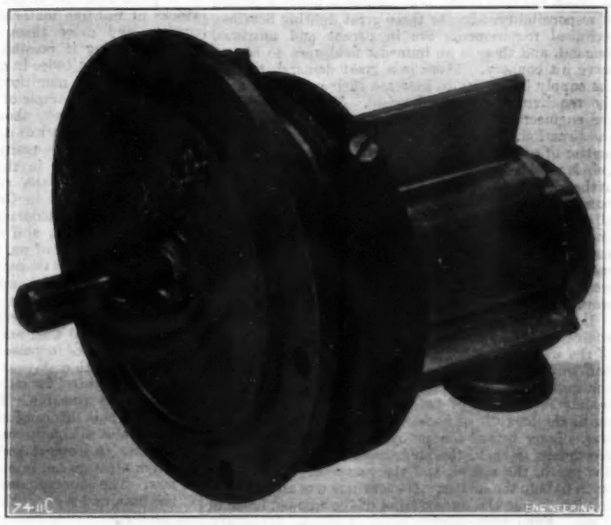


FIG. 2. PUMP WITH CASING WITHDRAWN.

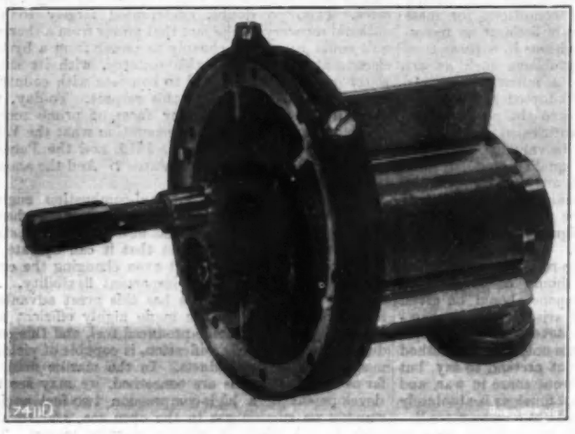


FIG. 3. REDUCTION-GEAR DRIVE.

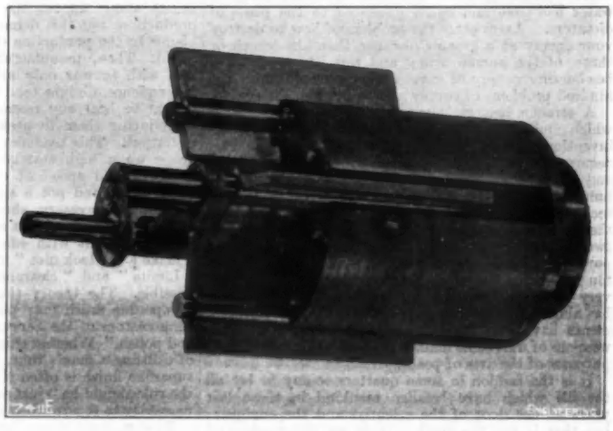


FIG. 4. ROTOR AND VANE ASSEMBLY.

ROTARY-VANE VACUUM PUMP.

THOUGH the rotary vane pump or compressor was developed in the early days of engineering and has since appeared in a wide variety of forms, special applications of the principle still provide opportunities for ingenuity of design coupled with other characteristics not specifically called for in other commercial products. A case in point is the rotary vacuum pump illustrated in Figs. 1 to 10, on this and the opposite pages. This pump is primarily intended for operating certain instruments forming an important part of aircraft equipment, a use postulating a number of requirements of unusual stringency, as compared with pumps or compressors employed for other purposes. Obviously, two of these requirements are the lightest possible weight and the smallest possible bulk, both as far as is consistent with strength and rigidity. Other essentials, apart from satisfactory efficiency, reliability and durability, are ease of access for assembly and dismantling, and ability to function at a low temperature. Interchangeability is a further requirement demanding precise workmanship and fine limits, and a very complete pressure-lubricating system functioning with a low oil consumption is also necessary. The pump has been patented and is manufactured by Messrs. Fenton-Smith Brothers, Mount Felix, Walton-on-Thames.

The external appearance of the pump is shown in Fig. 1, though it may be mentioned that certain variations in detail are required according to the type of engine from which the pump is driven. For example, the flange seen to the left in Fig. 1, which is for attachment to the engine, is circular; the driving shaft is splined, and the inlet and outlet ports are arranged at the side of the body. Reference to the drawings Figs. 5 to 7 will show, however, that the connecting flange is there of square form; the driving shaft is finished with a flat tongue and the ports are situated on the end of the body. These differences are pointed out chiefly in order to avoid possible confusion from want of coincidence in the several views, and they do not affect the principles of design or the construction of the rotating parts. For details of these parts the sectional views, Figs. 8 to 10, should be referred to in conjunction with the part-assemblies shown in Figs. 2 to 4. In connection with Figs. 1 to 3, it may be mentioned that coins were used to support the parts while they were being photographed, hence the otherwise inexplicable projection on the left-hand of Fig. 1 and on the right-hand of Figs. 2 and 3. The coins, however, serve to give a scale to the photographs as reproduced. Referring particularly to Figs. 8 to 10, it will be noted that the body of the pump comprises three main parts, viz., a cylindrical casing *a* having an integral back end; an intermediate plate *b*; and a cover *c*. The spindle *d*, round which the vanes *e* rotate, is mounted axially, with reference to the casing, at the back end but is cranked so as to enter the cover "off-centre," the object of this arrangement being to permit driving gears of small diameter to be used, the vanes not being driven directly but through reduction gears. The spindle is, of course, fixed and is hollow, both for the sake of lightness and to provide a passage for lubricating oil which leaves through small radial holes.

There are four vanes threaded on the spindle hinge-fashion, so that they are positively anchored radially but are capable of deflection round the shaft axis. The edges of the vanes are 0·001 in. clear of the interior of the casing. This clearance obviously removes the main source of friction in a rotary-vane pump but, perhaps, more important, renders it possible to employ light alloys for both the body and vanes, since there is no wear to guard against. Cast Elektron alloy is, therefore, employed for the body, intermediate plate and cover, and extruded Elektron alloy section for the vanes. The vanes are rotated by the rotor *f*, the axis of which is coincident with the cranked end of the spindle. This eccentricity naturally involves an asymmetrical disposition of the vanes, so that the angle at which they pass through the rotor is continually changing. This relative movement of vane and rotor is met by passing the vanes through slots in circular bars carried in the rotor, the bars forming trunnion bearings. The seal at the bottom of the pump in Fig. 9 is formed by the rotor, though here again, there is a minute clearance, to prevent friction and wear. At the same time, the oil film in shear is of sufficient thickness to resist air leakage from the pressure side to the suction side of the pump.

The construction of the rotor merits a detailed description. It consists not of a slotted cylinder but of two flanged end plates and four quadrantal segments between the vane trunnion bearings, the whole assembly being connected by the four through-

ROTARY-VANE LIGHT-WEIGHT VACUUM PUMP.

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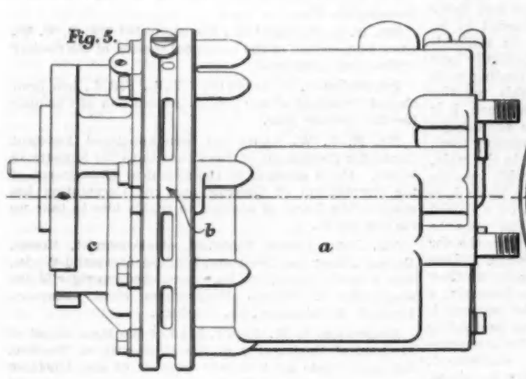
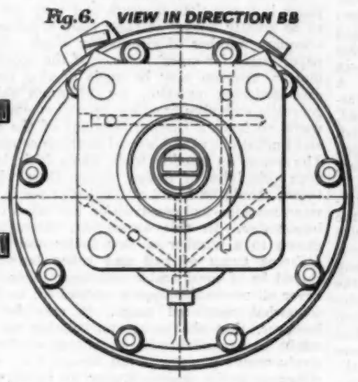
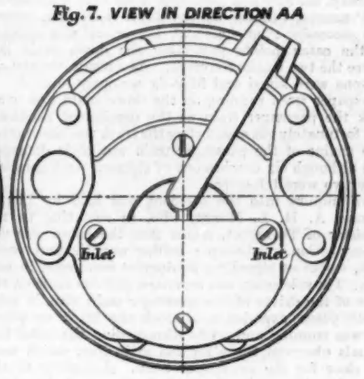
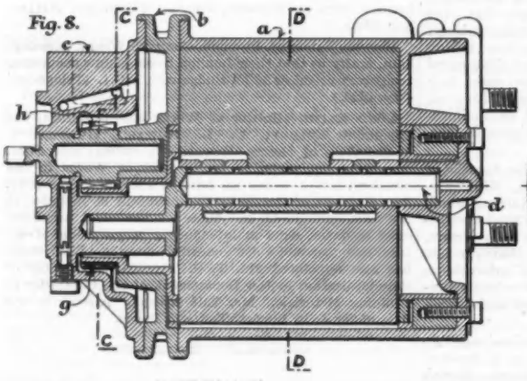
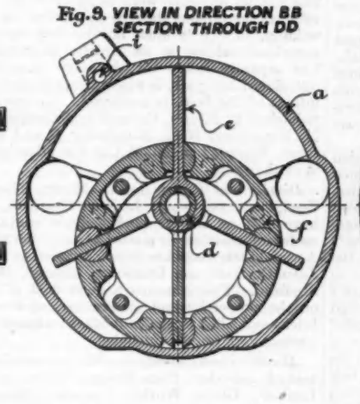
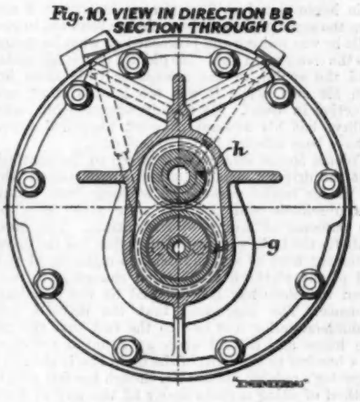












bolts seen in cross-section in Fig. 9. The ends of the trunnion bearings enter the end plates, as will be clear from Fig. 8, and can be inferred from Fig. 4. The end plates differ in construction. Taking that at the right hand of Fig. 8 first, it will be seen that it consists of a plain flanged tube, the body of which is carried in a bearing pinned to the end of the casing, while the flange carries the end of the trunnion bars and the quadrants are held in correct position by a dowel at each side of the through-bolts. The left-hand end plate has a similar but deeper flange and its body rotates in a bearing formed in the intermediate plate *b*. An extension of the body forms the driven gear wheel, the extension running clear of the boss on the cover in which the cranked end of the spindle is supported. The gear wheel is indicated at *g* in Figs. 8 and 10, and meshes with the driving pinion *h*. This pinion is integral with the driving shaft and runs in bearings formed in the cover at one end and in the intermediate plate at the other. It may be noted that accurate alignment of the casing, cover and intermediate plate is secured by recessing the flanges of the two former into spigots formed in the latter. The wheel arrangement is shown in Fig. 3.

Before describing the lubricating system some comments on the materials employed should be made. As already stated, the casing, intermediate plate and cover are cast in Elektron alloy. All are subjected to solution and precipitation heat treatments to give maximum strength and to reduce distortion to a minimum. They are protected against corrosion by the R.A.E. chromate-bath treatment (30 minutes treatment) after machining and are subsequently enamelled with Ikarol. The rotor segments are machined from a cylinder cast in the same alloy, the same material being used for the rotor bush in the end of the casing. These parts are subjected to the solution and precipitation heat treatments mentioned above, but do not, of course, need corrosion protection. The fixed cranked spindle, oscillating trunnions, rotor end plates, and driving pinion are machined from alloy-steel bar, hardened, tempered and ground as necessary. The hardened steel and Elektron alloy surfaces in contact result in a very satisfactory bearing combination and where steel is in moving contact with steel, viz., the trunnion ends in the rotor end-plates, a difference in Brinell hardness is provided which has also proved satisfactory. All holes are jig-drilled and, in some cases, jig reamed. The fits provided are either push fit or force fit, as required, and the limits are fine. Module 1 gears are used and are very durable in the hardened steel employed. The workmanship of such specimens of the pump as we have examined is excellent.

The lubricating system displays the same ingenuity of design as the other parts of the pump. All the bearings are pressure lubricated, the supply being derived from the engine lubricating system. The oil is distributed to the bearings from a common channel indicated at *i* in Fig. 9. This channel is fed either by an external pipe, which is connected to the boss seen near the channel in the figure, or by the standard position oil holes in the mounting flange of the cover shown in Fig. 6. If these holes are used, the hole in the boss is closed by a plug. The channel extends from end to end of the pump and from it individual supplies are taken to each bearing. As examples of these individual channels, that leading to the interior of the fixed spindle is seen in Fig. 7, the oil reaching the vane bearing surfaces by way of a pair of holes for each bearing. Similarly, the channels to the driving pinion bearings and the bearing of the front end plate are seen in Fig. 10. The channel for the driving pinion bearing in the cover can be seen to the left of Fig. 8. It is drilled from the exterior and plugged by a screw with a projecting end. This end limits the movement of a floating metering plug in the channel, the plug having a side clearance proportioned to the oil required for that particular bearing.

A metering plug is fitted to each bearing channel, though it has been omitted from some views to simplify drawing. The small annular space between the plug and its containing channel functions, moreover, as an efficient filter. The oscillating trunnions and the vanes passing through them are lubricated by the spindle oil supply. This supply, after passing the vane bearings, is discharged inside the rotor and is then subjected to centrifugal force which ensures its penetration to the trunnions and vanes. The gears are lubricated by the oil which passes out of the ends of the driving spindle bearings and the rotor bearings in the cover and the intermediate plate. All the oil reaching the pumping chamber, and forming the rotor air seal and lubricating the edges of the vanes next to the casing end and intermediate plate, has passed through the bearings and is clean. The plugs ensure correct control of the several oil flows and low oil consumption is therefore secured with adequate durability. In this latter connection it will be realised that a low oil consumption does not imply running on a low margin of safety since the vanes do not come into contact with the casing at all. It should be mentioned that the oil channels, where they cross from cover to intermediate plate and from this plate to the casing, are sealed against leakage by Dermatine washers, which are automatically compressed when the main joints between these parts are made.

The pump can be run in either direction, so that either of the holes seen in Fig. 7 can be used as the inlet or suction. The same adaptability applies to the side type inlets seen in Fig. 1. As regards performance, it will be realised that a maximum swept volume can be obtained in a pump of given dimensions owing to the large offset between the casing axis and the rotor axis, this volume being further increased by the varying included angle between the vanes since the vanes are radial to the casing and eccentric to the rotor. The rotor seal, at the bottom of Fig. 9, enables a very high internal compression ratio to be obtained and a maximum output when operating with a given pressure differential. The pump shown in Figs. 5 and 7 has an external diameter over the flanges of about 4 in., and has an overall length of about 5¼ in. It weighs only 2 lb. 4 oz. Its capacity, at a driving spindle speed of 1,500 r.p.m., is 7·7 cub. ft. of free air per minute when working with a suction of 4 in. Hg and a delivery pressure of 6 in. Hg, the output increasing in almost direct proportion to the speed, up to the maximum permissible driving spindle speed of 4,000 r.p.m. The temperature rise of the pump at 1,500 r.p.m. driving spindle speed and with the above suction and delivery pressures is 45 deg. C. The pump has been subjected to a complete calibration test entailing nearly 200 hours running time, from which test the above results were taken.

SOCIETY OF CHEMICAL INDUSTRY.—Dr. E. F. Armstrong, F.R.S., is to deliver the first H. E. Armstrong Lecture of the Society of Chemical Industry, at Burlington House, London, at 2 p.m., on February 3. The arrangements are in the hands of the London Section.

THE NORTON FITZWARREN RAILWAY ACCIDENT.

ON November 4, 1940, at Norton Fitzwarren, on the main West of England line of the Great Western Railway, the 9.50 p.m. passenger train from Paddington to Penzance, running on the down relief line, passed two successive stop signals at danger and was derailed at the catch points protecting the down main line where the two tracks converge. As a result, twenty-six persons were killed and fifty-six seriously injured. A newspaper train running on the down main line overtook the passenger train as the derailment occurred, but fortunately got clear before the track was obstructed. The engine of the passenger train was little damaged and although six coaches out of thirteen were derailed, only two were telescoped.

An inquiry into the accident was held by Lieut.-Colonel A. H. L. Mount, who, in reporting to the Minister of Transport, states that the cause was not enemy action or sabotage; neither were the permanent way, works or signalling equipment concerned in any way. The sole cause was an unaccountable lapse on the part of the driver of the passenger train who, in spite of 40 years' experience, mistook the track on which he was running and while disregarding the relief line signals observed those for the main line, which were all clear for the newspaper train. According to the driver's evidence, he observed the down relief to down main home signal at Taunton station, some 2 miles from the scene of the accident, change from red to green while he was waiting and proceeded on what he thought was the down main line. He did not realise his mistake until the engine of the newspaper train drew level with his own, when it was too late to effect much reduction in speed. He frankly admitted his responsibility, but his account of what happened appears to have been affected by his experiences.

Colonel Mount was, in fact, forced to the conclusion that the driver's memory of the circumstances which led to his initial mistake on starting from Taunton was unreliable and that his error must have been the outcome of failure to concentrate. The normal route for the train was via the main line, but the driver's statement that he saw the relief to main signal at the end of the platform at Taunton change from red to green was definitely contradicted by the signalman's evidence. The suggestion that the driver's initial misunderstanding was due to the fact that the relief line home and distant arms at Taunton are carri d on a bracket to the right of the main line is also, in the inspector's opinion, untenable, though the fact that this method of siting persists nearly all the way to Norton Fitzwarren may have prevented him from realising his mistake sooner. The driver himself stated that he did not receive an automatic train control siren warning or brake application, but after the accident the train control apparatus, both on the ground and on the engine, was proved to be in working order.

Previously, the driver's record had been one of consistent reliability and it is therefore difficult, Colonel Mount said, to understand the reasons for such a lapse. Nevertheless, in spite of his knowledge of the road, the erroneous impression which he gained on leaving Taunton and retained for more than 3 minutes was apparently due, in the first instance, to interpreting incorrectly a simple and well displayed group of four signal lights. Thereafter, the automatic train control warning, unfortunately, did not have the desired effect, as it undoubtedly has in other cases. The issue, Colonel Mount considers, is largely psychological. The driver was fit and did not lack rest. His breakdown, however, may be partly attributed to operating conditions in the black-out and to the general strain which railway servants, in common with other members of the community, are undergoing at the present time. Colonel Mount does not think there is any reason why information, additional to that provided by the directing signals, should be given when trains running out of course are diverted from their normal route, or that the driver's position on the right-hand side of the footplate, as is the Great Western Company's practice, had any bearing on his failure to observe the signals on the left-hand side of the road. Nevertheless, similar mistakes have occurred in the past and signals have been re-sited where their locations may have confirmed a driver's erroneous impression. The possibility of momentary confusion in darkness and bad weather is obviously greater and the circumstances of this accident show that where parallel lines exist any steps which are reasonably practicable should be taken to site signals where they enable drivers instinctively to verify the line on which they are travelling. Standardisation of practice in this respect is insisted upon abroad and is fairly general in this country. Colonel Mount is of opinion that this point should receive closer attention in connection with any new widenings that may be undertaken and when opportunity occurs it would be well to review the position at Taunton and at other places where there are parallel lines.

ANNUALS AND REFERENCE BOOKS.

Mechanical World Year Book, 1941.—This well-known pocket book retains its handiness and practical characteristics in spite of the additions accompanying its annual revision. The disappearance of the diary pages is a war-time measure and they are not likely to be greatly missed as their place is occupied by an adequate number of alternating blank and squared-paper pages for users' notes. Of the specifically new matter, mention may be made of that dealing with case-hardening practice, for, although this practice generally embodies handling by expert craftsmen, it is useful to have a succinct account of the advantages and limitations of the several methods commonly used. The section on machine tools, which deals, in the main, with principles of design rather than with specific types, should be found of particular use in these days when machine-tool construction has taken on a special importance. In this connection, attention may be drawn to a number of new tables and formulæ for different types of ball and roller bearings. These should be of considerable assistance in design as they cover all reasonable speeds instead of, as formerly, a somewhat restricted range. It may be suggested, however, that the paragraph relating to preloading might be expanded with advantage as this comparatively recent practice is not always fully understood, either as to its desirability or its liability to abuse. The section on press work is likely to have a special value at the present time, as also is that on electric arc welding, though it must not be forgotten that oxy-acetylene welding is an equally important subject. The separate index for the very numerous tables, introduced last year, is wisely retained and the general format of the book is unaltered. As previously, it is published by Messrs. Emmott and Company, Limited, 31, King-street West, Manchester, 3, and 28, Bedford-street, Strand, London, W.C.2, the price being 2*s.* net, in cloth covers.

Diaries and Pocket Books.—Messrs. The Associated Equipment Company, Limited, Southall, Middlesex, have sent us a neat pocket diary containing much useful information for motorists and other road users.—A useful little diary has been forwarded to us by Messrs. John G. Stein and Company, Limited, Bonnybridge, Scotland. This contains a good deal of information on the properties and applications of the firm's fire-bricks and silica bricks, and other technical and miscellaneous data are also included.

Almanacs and Calendars.—We have received monthly tear-off calendars from Messrs. Robey and Company, Limited, Globe Works, Lincoln; Messrs. British Insulated Cables, Limited, Prescot, Lancs.; Messrs. H. Franklin and Company, Gedling-street, Dockhead, London, S.E.1; and Messrs. Ruston-Bucyrus, Limited, Excavator Works, Lincoln.—Daily tear-off calendars have been sent to us by Messrs. Raybestos-Belaco, Limited, Asbestos House, Southwark-street, London, S.E.1; and Messrs. S. S. Stott, Limited, Haslingden, Rossendale, Lancs.—Messrs. The Associated Equipment Company, Limited, Southall, Middlesex, have sent us a useful weekly tear-off desk diary and engagements pad.—A two-monthly tear-off wall calendar has been received from Messrs. Ruston and Hornsby, Limited, Lincoln.—Messrs. Liverpool Marine Appliances, Limited Cunard Buildings, Pierhead, Liverpool, 3, have sent us daily refills for their desk calendar and memorandum tablet.—A wall calendar with three months on each page has reached us from Messrs. C. A. Parsons and Company, Limited, Heaton Works, Newcastle-upon-Tyne, 6.

NON-FERROUS METALS CONTROL.—Commencing on January 1, the following alterations are made to the arrangements set out in the circular letter issued by the Non-Ferrous Metals Control on June 6, 1940. The weight of copper and copper alloys to be used by any manufacturer in the production of gas or electric water heaters of all types, and wash boilers and washing machines, electric lamp holders (except inserts, terminals and contacts), and electric conduit bushes, connectors and fittings of all types, is to be restricted to ten per cent of the tonnage used by the manufacturer in the year ending June 30, 1939. This 10 per cent. quota is granted for the home civil trade, and requirements for export and for Government Departments should be applied for separately and will be considered on their merits. The tonnage of metal obtained by any manufacturer during any one quarter of a year must not exceed one quarter of the annual quota allowed on the above basis. Apart from these alterations, the other restrictions and conditions set out in the letter of June 6 still apply. Manufacturers who adhere to the scheme set out in the letter of June 6, as amended in the new letter (dated December 24, 1940), should quote the symbol "N.F.G. 1941" in the case of gas appliances, and "N.F.E. 1941" in that of electrical accessories and appliances, when ordering from their suppliers, who must quote these symbols on the schedules submitted to the Non-Ferrous Metals Control.

PERSONAL.

THE University of Manchester has conferred the Degree of Doctor of Science, *honoris causa*, on MR. HANS RENOLD, J.P., a director of Messrs. Renold and Coventry Chain Company, Limited, Renold Works, Didsbury, Manchester, 19.

MR. H. E. POTTS, M.Sc., has succeeded MR. B. D. W. LUFF as chairman of the Liverpool Section of the Society of Chemical Industry.

PROFESSOR F. G. DONNAN, C.B.E., F.R.S., has been elected President of the British Association of Chemists for the ensuing year.

MR. R. G. W. EADIE has been appointed Assistant Controller (Technical) of Tar Products to the Ministry of Mines. He is engaged in the Chemical Department of the Corporation of Glasgow and the Corporation has granted him leave of absence to enable him to take up his new duties.

MR. JOHN LLOYD BENTLEY, chief chemist, Messrs. Dorman, Long and Company, Limited, Cleveland Works, South Bank, Yorks, has been appointed manager of the steelworks of Messrs. Wolsingham Steel Company, Limited, Wolsingham, Co. Durham.

PROFESSOR R. W. ANGUS, head of the Department of Mechanical Engineering of the University of Toronto, has been made an honorary member of the American Society of Mechanical Engineers.

THE DEPARTMENT OF OVERSEAS TRADE has opened a London office at Millbank, S.W.1. (Telephone, WHItehall 9040.)

MESSRS. TANGYES, LIMITED, Cornwall Works, Birmingham, notify us that their London house is now occupying temporary premises at 28, Budge-row, E.C.4. (Telephone, City 4324.)

LORD REITH, Minister of Works and Buildings, has appointed COLONEL C. L. HOWARD HUMPHREYS, M.Inst.C.E., of Messrs. Howard Humphreys and Sons, consulting engineers, to be Director of Works in the Ministry, a post which has been in abeyance since 1927. The divisions of the Ministry which will be included in the new directorate are those of the chief architect, chief engineer, chief maintenance surveyor, chief structural engineer and chief quantity surveyor. Lord Reith has also appointed MR. T. S. TAIT to be Director of Standardisation in the Department of the Controller of Building Materials. Mr. Tait is senior partner in the firm of Sir John Burnet, Tait and Lorne.

TENDERS.

WE have received from the Department of Overseas Trade, Millbank, London, S.W.1, particulars of the undermentioned tenders, the closing dates of which are as stated. Details may be obtained at the above address, quoting the reference numbers given.

Earth Plates and Wires, 400 of each, in accordance with the N.Z. Post and Telegraph Department Specification No. 269, except that the standard diameter of the earth wire shall be 0·128 in. Post and Telegraph Department, Wellington, N.Z.; February 17. (T. 23,547/40.)

Switchgear, metal-clad, indoor-type, 415-volt, three-phase, 50-cycle. City Electric Light Company, Limited, Boundary-street, Brisbane, Queensland, Australia; February 6. (T. 23,623/40.)

Air Compressor, portable. Union Tender and Supplies Board, Pretoria; February 13. (T. 23,640/40.)

Boiler Plant, comprising two self-contained Economic steam boilers and two underfeed automatic stokers for Alexandra Mental Hospital, Cape Town. Union Tender and Supplies Board, Pretoria; February 6. (T. 23,643/40.)

Electricity Meters, 347, of various types. City Electrical Engineer, Salisbury, Southern Rhodesia; March 10. (T. 23,645/40.)

Electricity Meters, 3,000, single-phase, 10-ampere, 230-volt, 50-cycles. Municipal Electricity Department, Singapore, or office of inspecting engineers, Messrs. Peirce and Williams, chartered civil engineers, 1, Victoria-street, London, S.W.1; January 17. (T. 23,653/40.)

Wheels and Axles, in accordance with a given specification. South African Railways and Harbours, Johannesburg; February 10. (T. 23,638/40.)

THE SWANSEA STEEL-SHEET INDUSTRY.—The market report issued by the Incorporated Swansea Exchange, Royal Metal Exchange, Swansea, for the last week of 1940, states that the tin-plate industry continues active and that a fair volume of business is being done with both home and overseas clients. Ordinary commercial business in galvanised and other steel sheets, however, is restricted, as the huge priority demand continues to absorb the bulk of the production. There is a good demand for iron and steel scrap.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—It was announced that, from January 1, South Wales miners' wages were to be increased, in common with those of mineworkers in all the coalfields of the country, under an agreement entered into between the miners and owners earlier this year. As a result of this, the miners, whose wages have now been associated with the cost of living index, have received total war-time increases of 2*s.* 4*d.* per shift in respect of adult workers and 1*s.* 2*d.* for youths. The latest increases were in respect of 6*d.* per shift for adults and 3*d.* for youths. Operations on the steam-coal market with inland users proceeded on active lines. Buyers in this direction were still displaying a keen interest in respect of the high-volatile bituminous coals which were almost completely disposed of for a long time ahead. Dry steams, however, received little support and producers of these kinds were only quietly employed. Best large qualities were moving off satisfactorily, while the popular sized sorts were not easy to stem over a long period. Bituminous smalls remained scarce, but the dry smalls were readily available and were dull. Cokes were active, but patent fuel was still slow.

The Iron and Steel Trade.—Activities in the iron and steel and allied trades were well maintained in spite of the holidays. The demand showed no indication of easing and producers generally held well-filled stem lists.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—Throughout the past year, outputs of all types of products have steadily increased; extensions to many works have been carried out, and additional plant has been installed. Sheffield industrialists, although satisfied with the present level of production, are taking energetic steps to augment the current output. The greater part of the production in this locality is being used for the Services, but many of the large steel and engineering works are managing to execute an increasing volume of ordinary commercial business. Sheffield, in fact, is supplying large quantities of steel to industrial centres in various parts of the country. The raw and semi-finished steel trades are now operating some furnaces which had recently been put out of action for overhauls. Basic steel is a strong line, and acid steel is also in active request. The local works continue to import large tonnages of hematites, pig iron, and steel-making alloys, and few complaints are heard of difficulties in obtaining adequate supplies; the scrap position is quite satisfactory. In the machinery and heavy engineering branches, the situation is encouraging. Railway rolling stock is in steady demand on both home and overseas account, and Sheffield works are fully occupied in turning out heavy tonnages of shipbuilding steel and related products. The call for structural steel also has been well maintained, and more business is passing in steelworks and ironworks machinery and plant, notably in rolling mills, forges, presses, and furnaces of all types. Electrical equipment is a satisfactory line. Makers of special alloy steels are exceptionally busy; the outputs of motor-car and aircraft steels are accounted for for many months ahead, and stainless steel is in demand for a variety of purposes. Dairy-equipment makers and agricultural engineers are particularly heavy buyers. All types of agricultural-engineering products are in good demand, as the forthcoming season promises to be a record one. The tool trades are operating at full capacity.

South Yorkshire Coal Trade.—The inland demand for all classes of fuel has been well maintained, and no difficulty has been experienced in transport. There is a brisk demand for industrial coal, and locomotive fuel is in request. The house-coal market shows further improvement, and sales are well above the seasonal average. Foundry and furnace cokes are steady media.

HIGH-STRENGTH HIGH-CONDUCTIVITY COPPER ALLOYS.—A pamphlet just issued by Messrs. Mallory Metallurgical Products, Limited, 78, Hatton-Garden, London, E.C.1, describes the properties and applications of the firm's range of high-strength high-conductivity copper-alloy castings. We understand that the alloys possess good mechanical strength and hardness, as well as high current-carrying capacity, and that they have found successful applications in several different types of electrical equipment, including circuit breakers, arc and induction furnaces, and resistance-welding machines. The tensile strengths of castings of Mallory "3," "53" and "100" alloys are quoted as being, respectively, 22 tons, 32 tons, and 45 tons per square inch, and their electrical conductivities as 80 per cent., 40 per cent., and 45 per cent. that of standard copper. The Brinell hardness of the alloys ranges from 110 to 225.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—There are few new features in the iron and allied trades of this district, but the slight changes noticeable are for the better. The total output, supplemented by substantial imports, is sufficient for the actual requirements of customers for most commodities, but users of certain descriptions of material are pressing for larger deliveries. Delivery allocations over the first quarter of the year have been followed by substantial bookings, and buyers are desirous of placing further orders. The demand for commodities for ordinary industrial purposes is considerable, but the cautious issue of licences for distribution of tonnage for other than war-time needs still confines ordinary commercial business within narrow limits.

Cleveland Iron Trade.—The parcels of foundry iron reaching consumers' works are adequate for current needs. No improvement can be reported yet in the irregular make of Cleveland pig, and any material increase in production is unlikely while ample supplies of foundry iron are obtainable elsewhere. The extensive use of Midland makes continues in this area and the tonnage required for purposes particularly specified is still being received from Scotland and other foundry-iron producing centres. Rather more iron is passing through second hands than has been the case recently, but the tonnage obtainable by merchants is still rather small. The stabilised values of Cleveland pig remain at the level of No. 3 quality at 128*s.*, delivered in the Middlesbrough district.

Hematite.—The heavy make of hematite falls rather short of the large and expanding demand, but the steadily increasing imports of American products are relieving the pressure for supplies of local brands. Hematite consumers are satisfied with the quality of the iron coming from overseas and readily accept parcels as they arrive. Merchants are now able to secure the control of sufficient tonnage to meet the requirements of regular customers. The makers' own consuming works are absorbing the greater part of the output of hematite, but users who have to enter the market for supplies are receiving better deliveries under running contracts than has been the case for some time. Official values of East Coast brands remain at the equivalent of No. 1 description at 138*s.* 6*d.*, delivered to North of England buyers.

Basic Iron.—The make of basic iron is still ample for the heavy requirements of the local steelworks, but provides no tonnage for other purposes. The fixed price still stands at 120*s.*

Foreign Ore.—The situation as regards foreign ore is satisfactory. Stocks are good and imports are expected to be maintained.

Blast-Furnace Coke.—The fixed figure for good medium blast-furnace coke is 35*s.* 6*d.*, but there is little business passing. Sellers have good order books and local consumers are well covered.

Manufactured Iron and Steel.—The deliveries of semi-finished iron and steel are still quite adequate for the large requirements of the re-rolling mills, and the total make of finished products is being maintained at a very high level. Record outputs of all kinds of sheets are being obtained and there is a heavy demand for shipbuilding requisites. Among the principal quotations are: Soft steel billets, 12*l.* 5*s.*; hard billets, 13*l.* 12*s.* 6*d.*; joists and sections, 15*l.* 8*s.*; heavy plates, 16*l.* 3*s.*; and heavy rails, 14*l.* 10*s.*

Scrap.—Users of iron and steel scrap are steadily increasing their already heavy stocks.

CENSUS OF STOCKS OF IRON AND STEEL PRODUCTS.—The Iron and Steel Control has been asked by the Ministry of Supply to take a complete census of the stocks of steel held by users. The inquiry relates to the stock position at the end of December, and the form sent out by the Iron and Steel Control must be completed and returned by January 11, so that the results are available by the middle of the month. In addition to stocks, the total receipts and consumption of steel in the last quarter of 1940 are asked for. The list of firms who are being written to has been built up from lists of customers of representative steel firms in each area, and although the number of firms being approached runs into many tens of thousands, some important, though not necessarily large, users of steel may have been omitted. As it is most desirable that every user of steel should be covered by the inquiry and should be on the Control's list of steel consumers, any firm which has not received a letter within the first few days of January is asked to write to the Iron and Steel Control, Hemingford, Alveston, near Stratford-on-Avon, for the necessary form. Stocks of tin-plates in the hands of users are not covered by the form, as the particulars are already available to the Control.

NOTICES OF MEETINGS.

IT is requested that particulars for insertion in this column shall reach the Editor not later than Tuesday morning in the week preceding the date of the meeting.

INSTITUTION OF MECHANICAL ENGINEERS.—To-day, 2 p.m., Storey's-gate, St. James's Park, S.W.1. Special Informal Meeting. Discussion on "The Control of Oil Fires," to be opened by Mr. A. F. Dabell.

JUNIOR INSTITUTION OF ENGINEERS.—Saturday, January 11, 1.30 p.m., 39, Victoria-street, Westminster, S.W.1. Ordinary Meeting. "Electrical Wiring Regulations and Their Application," by Messrs. E. H. Whatton and T. Hall. *Midland Section:* Saturday, January 11, 3 p.m., The James Watt Memorial Institute, Birmingham. Ordinary Meeting. "Some Problems of Electricity Distribution," by Mr. Donald Birch.

INSTITUTE OF BRITISH FOUNDRYMEN.—*Lancashire Branch:* Saturday, January 11, 3 p.m., The Engineers' Club, Albert-square, Manchester. "Sands," by Mr. W. Y. Buchanan. *Scottish Branch:* Saturday, January 11, 3 p.m., The Royal Technical College, George-street, Glasgow. "Apprentices and Foundry Planning," by Mr. James Arnott.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—At the close of 1940 the Scottish steel trade was still operating at its maximum capacity and throughout the year the tonnage produced has been a record. The past week has been no exception, and the demand for all kinds of steel material has been on a large scale; so large that the annual year-end holiday has been curtailed to one day in many cases. To-day the works are mostly in operation, and production is going on as usual. Shipbuilders and boiler-makers have been pressing for deliveries and the demands of other consumers are also very heavy and persistent. In the black steel-sheet trade, the orders on hand amount to a large tonnage, galvanised sheets being in particularly heavy demand. In the steel trade in general, the repairs and overhauls of plant which are normally carried out at this time have been reduced to the minimum. The following are the current quotations:—Boiler plates, 17*l.* 0*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black steel-sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton.

Malleable-Iron Trade.—In the West of Scotland malleable-iron trade there has been little change during the week and plant has been fully employed. Very satisfactory bookings for the new year have been reported. The re-rollers of steel bars have heavy order books and forward bookings represent a large tonnage. To-day's quotations are as follows:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—Active conditions continue to rule in the Scottish pig-iron industry and the whole of the current output is rapidly taken up. With ample supplies of iron-ore, production is being maintained at a maximum. All furnaces are being kept in full blast at present. The current market prices are as follows:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steelworks; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* 6*d.* per ton, both on trucks at makers' yards.

MESSRS. HENRY SIMON'S CALENDAR.—In addition to those regular features of Messrs. Simon's calendar which render it acceptable to so many of the firm's friends, there are two special reasons why the 1941 issue will be more than usually welcome. One is that this issue marks the jubilee of the calendar, which was first sent out 50 years ago, the mottoes or quotations for each day then being selected and arranged by Henry Simon, founder of Henry Simon, Limited, and Simon-Carves, Limited, and his wife. Since 1916, this work has been carried on by their eldest daughter, Lady Hamilton, Cransford Hall, Saxmundham, Suffolk, who would be glad to receive suggestions regarding new quotations for inclusion in future issues of the calendar. The other reason why the current edition of the calendar will be particularly welcome is that regular recipients must have felt some misgiving regarding the possibility of issuing the calendar in the present circumstances, and they will be glad to find that any difficulties have been overcome. It is hardly necessary to mention that the calendar is of the daily tear-off type and for each day an inspiring, encouraging or entertaining quotation is given. The address of Messrs. Henry Simon, Limited, is Cheadle Heath, Stockport.

NORRIS DAM ON THE CLINCH RIVER, TENNESSEE, U.S.A.

(*For Description, see page* 1.)

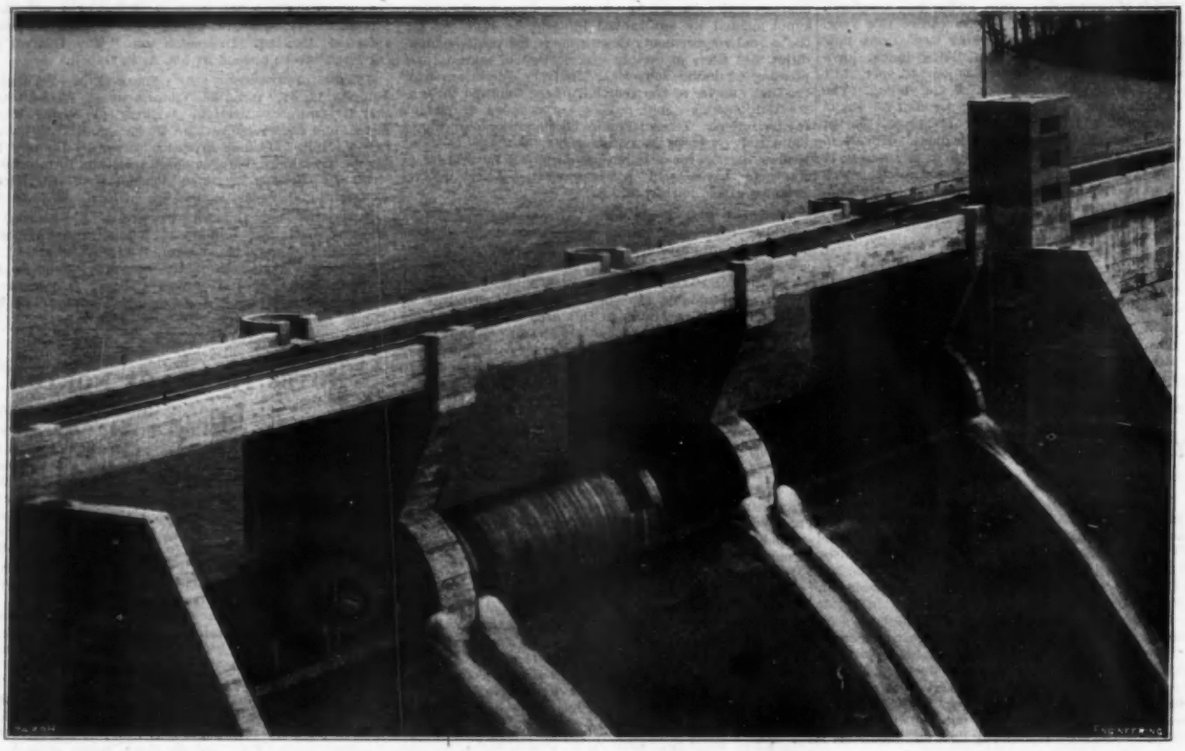
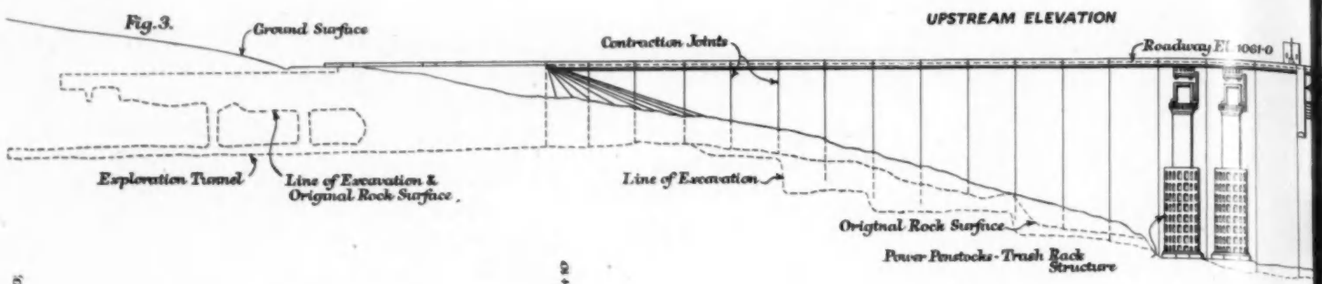


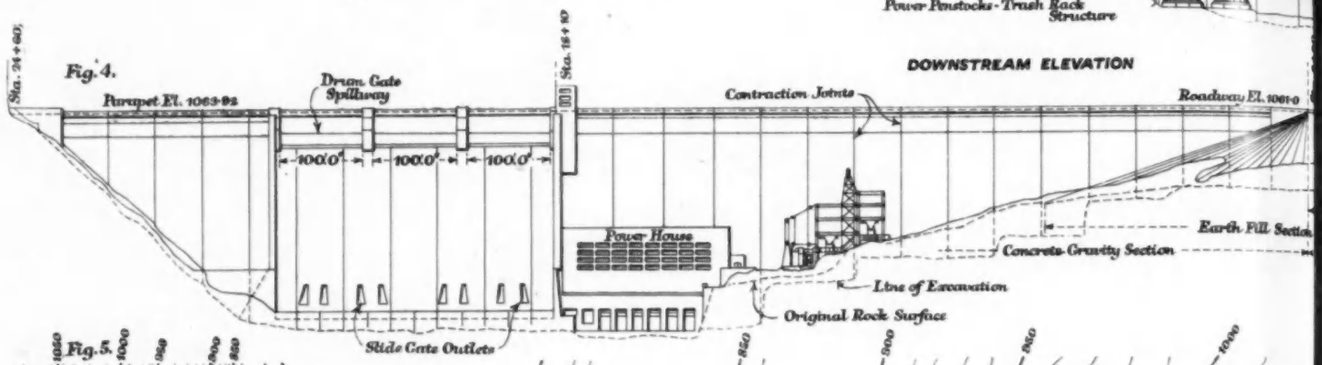
FIG. 15. SPILLWAY GATES IN THE RAISED POSITION.

FIG. 16. UPSTREAM FACE OF DAM SHOWING TRASH RACKS.

THE NORRIS DAM ON THE CLINCH

(For Description see page 1.)





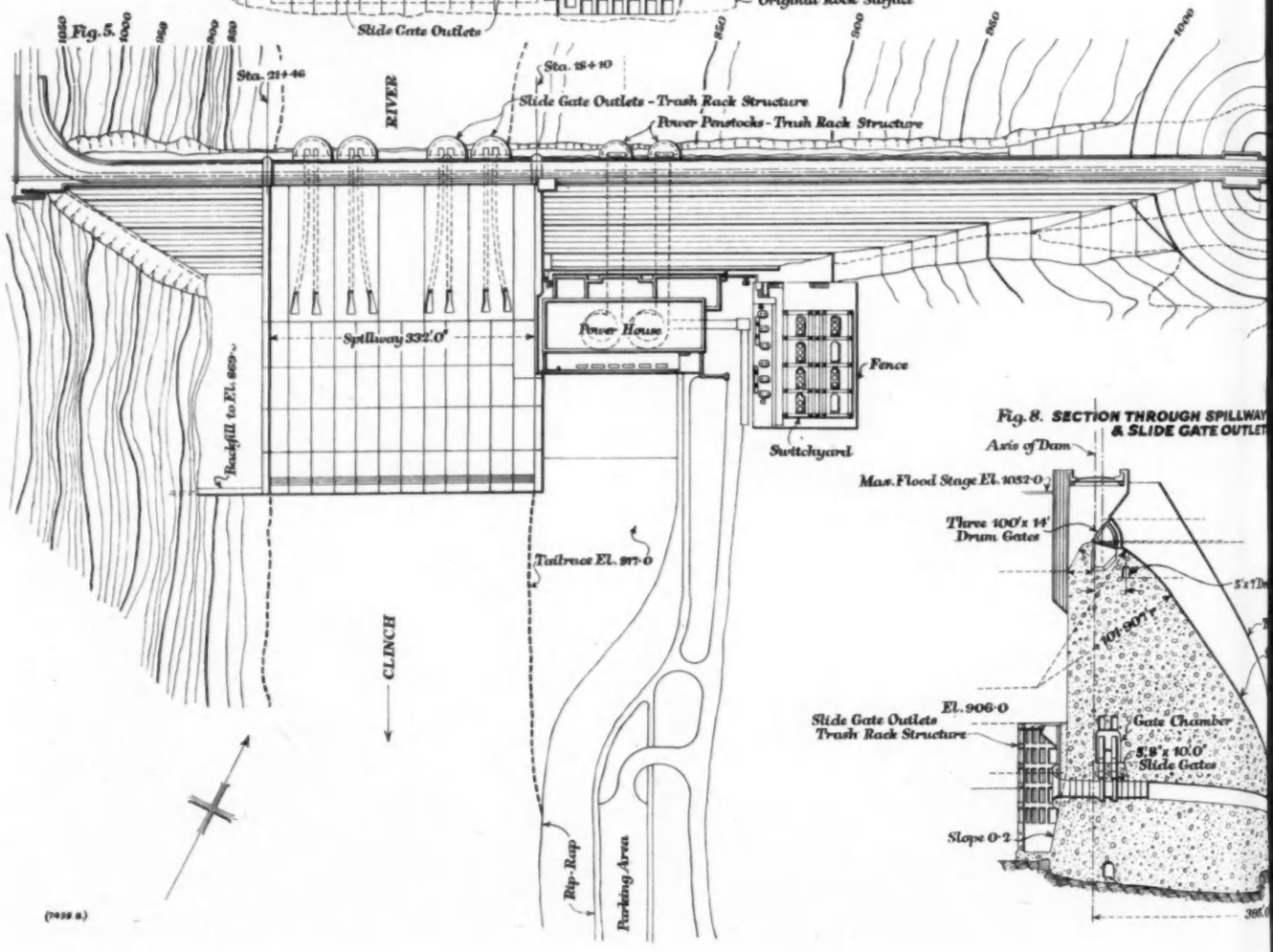


Fig. 8. SECTION THROUGH SPILLWAY & SLIDE GATE OUTLET
Axis of Dam
Max. Flood Stage El. 1052·0
Three 100'x 14' Drum Gates
El. 906·0
Slide Gate Outlets Trash Rack Structure
Gate Chamber
5'8" x 10'0" Slide Gates
Slope 0·2

CINCH RIVER, TENNESSEE, U.S.A.

(Description on page 1.)

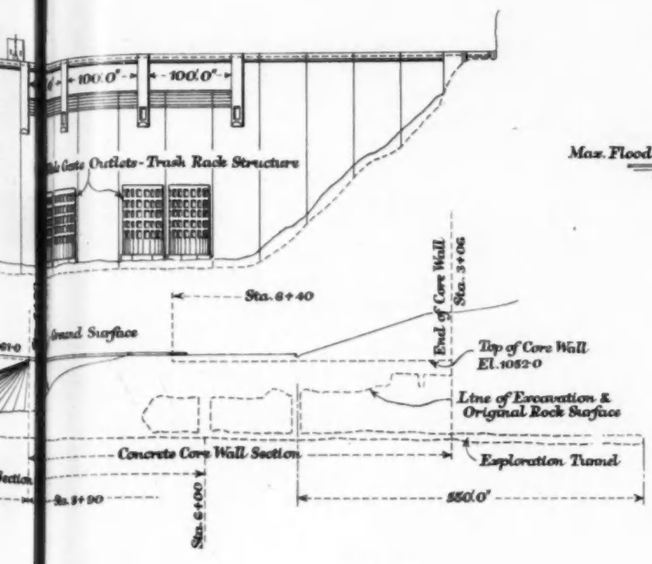
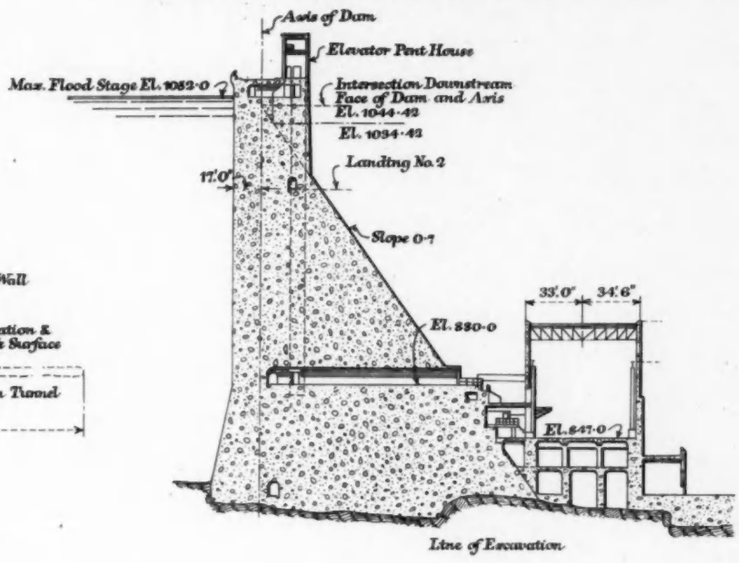


Fig. 6. SECTION THROUGH WEST END OF POWER PLANT



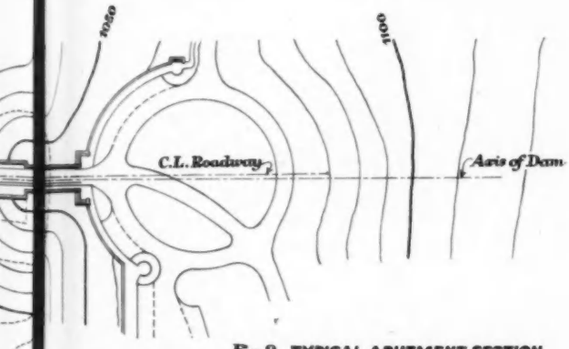


Fig. 7. TYPICAL EARTH FILL SECTION

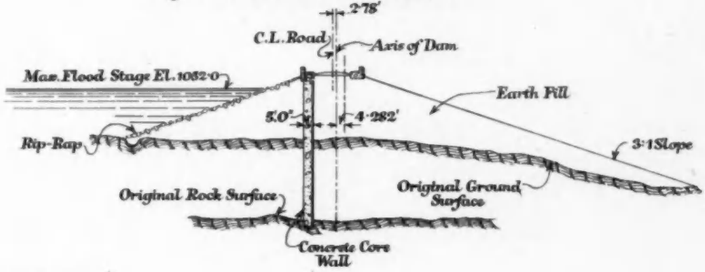


Fig. 9. TYPICAL ABUTMENT SECTION

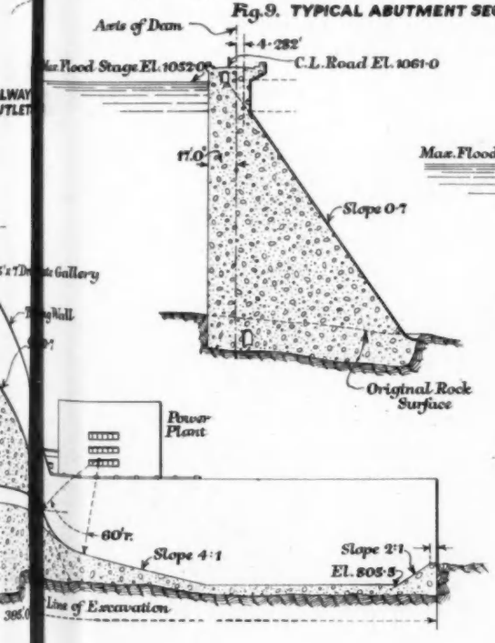
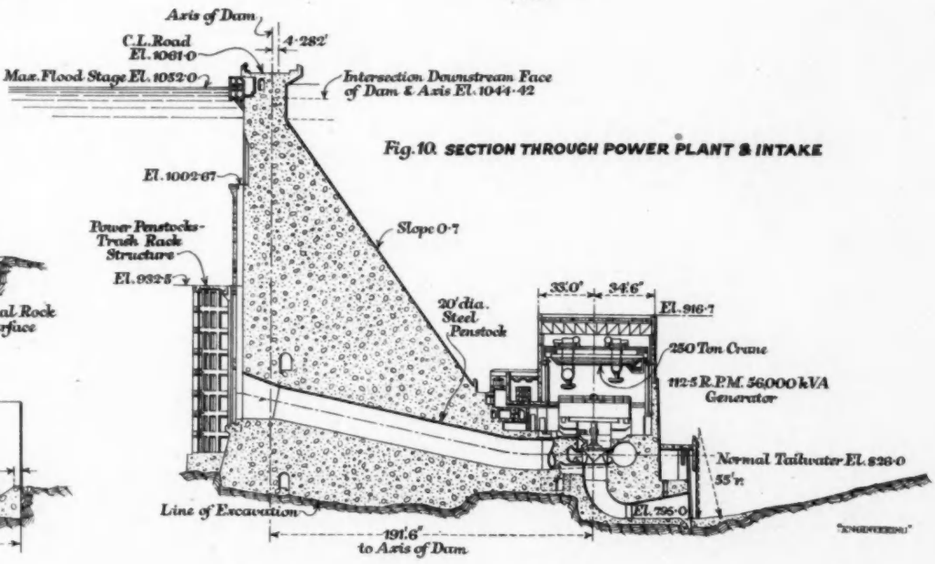


Fig. 10. SECTION THROUGH POWER PLANT & INTAKE



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ENGINEERING.

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Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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ENGINEERING

FRIDAY, JANUARY 3, 1941.

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SEVENTY-FIVE YEARS.

LAST week's issue of ENGINEERING marked the completion of 75 years' publication, uninterrupted save by the fortnight's hiatus caused by the General Strike of 1926, which affected all periodicals alike, and, therefore, may be left out of the account. It is true that a mere three-quarters of a century makes but a modest show beside the 250 years of *Berrow's Worcester Journal* (which celebrated that achievement some ten days ago) or the 206 years of *Lloyd's List*. There are, in fact, a full score of British periodicals which can look back upon more than 200 years of active life, and there must be nearly a century of centenarians. ENGINEERING, however, has enjoyed throughout those 3,913 weeks a distinction that belongs to none of these, in its faithful delineation of the technical developments that have made possible the vast changes in the industrial, commercial, social and economic structure of civilisation between January, 1866, and January, 1941. Whether the changes are all improvements is, perhaps, matter for controversy; but they are sufficiently varied and widespread to induce the belief that, instead of a review of the progress of 1940 only, a more extended survey might be of interest, as an accompaniment to some brief account of the genesis of this journal, its subsequent progress, and the leading personalities responsible for its initiation and direction.

The wave of interest in things technical, which had grown out of the so-called "Industrial Revolution," crystallised into a general urge towards the acquisition of scientific knowledge of all kinds in the early years of the Nineteenth Century. The extensive and, for those days, spectacular engineering works involved in the building of railways, the improvement of road communications, shipbuilding in iron, and the expanding mechanisation of industrial processes on every hand provided a nation-wide stimulus in this direction which was reflected in the popularity of mechanics' institutes, and of the various encyclopædic publications of the early Victorian era. Fresh impetus was given to this movement by the Great Exhibition of 1851 and its successor of 1862. Thus, by the autumn of 1865, when that wayward and erratic genius, Zerah Colburn, was formulating his plans for the establishment of ENGINEERING, an appreciable proportion of the 30 millions which formed the population of the British Isles were, in the modern phrase, definitely "science-minded."

Certainly, there was no lack of great engineering undertakings to whet their interest. The Mont Cenis tunnel works had been in progress for nearly 20 years and work on the Suez Canal was well advanced. Nearer home, the Metropolitan District Railway, the Victoria Embankment, and Sir Joseph Bazalgette's scheme for the disposal of London's sewage by the Northern and Southern Outfalls were all in hand, and the rebuilding of Westminster Bridge had been but recently completed. In 1865, the Great Eastern had laid nearly 1,200 miles of the second cable across the Atlantic, when it parted and the attempt had to be abandoned for that year. A third cable was laid in the following year, and the 1865 cable completed; an achievement which was recognised by the bestowal of knighthoods on Professor William Thomson (afterwards Lord Kelvin), Samuel Canning (engineer-in-charge for the contractors), Daniel Gooch (representing the owners of the Great Eastern) and Captain James Anderson (commanding the Great Eastern).

Other technical developments which were much under discussion at the time included Bessemer steel; the use of hot-blast stoves in the iron industry; iron armour for warships, and the relative merits of the broadside fighting ship and the turret ship; compounding as applied to marine engines; corrosion of metal structures; and improvements in guns and gunnery. Electric power and lighting were still some way from the stage of practical application, although the dynamo had been brought to some degree of perfection at the hands of Wilde, Varley, Wheatstone, Werner von Siemens and others. Telegraph systems were spreading rapidly, and extensions to the railway systems of the British Isles were still being made, while much British capital and enterprise was employed in railway development overseas.

Warship design in 1865-66 was still in a state of transition, not having become fully adapted to either the use of armour or of steam propulsion. The Royal Navy of that time included iron-armoured iron ships, iron-armoured wooden ships, unarmoured wooden ships, and paddle and screw vessels of both iron and wood. All ships had masts and yards, and even the steam vessels did much of their work under sail. The most notable ships in the fleet were the Warrior and Black Prince. Naval engineering opinion was divided regarding the respective merits of simple and compound engines. In 1865, Macfarlane Gray fitted the Great Eastern with the first steam steering engine. In the following year, the Admiralty, through Mr. (afterwards Sir) E. J. Reed, then chief constructor, authorised Messrs. Laird Brothers to build a masted turret ship according to the design of Captain Cowper Coles; this was H.M.S. Captain, which capsized off Cape Finisterre in 1870. In 1866, too, the Admiralty made another experiment, by fitting the gunboat Waterwitch with jet propulsion on the Ruthven system. An incident of 1865 which may be mentioned, also, was the floating, out of the dock in which she was built by the same firm, of the ironclad Agincourt—"this monster armour-plated ram, of 6,680 tons burden and 1,350 horse-power," as a contemporary writer described her; so far as can be known in war time, she is still afloat.

In naval and mercantile shipbuilding, Robert Napier, John Elder, and John and George Thomson were prominent figures on the Clyde; Edward Harland and G. W. Wolff were well established in their shipbuilding partnership at Belfast, as Charles Mark Palmer was at Jarrow-on-Tyne. Alfred Yarrow and John I. Thornycroft both founded the firms which bear their respective names in 1866, the former at Poplar and the latter at Chiswick; but the Thames, as a shipbuilding centre, was then more intimately associated with Scott Russell, John Penn, and the firm of Maudslay, Sons and Field. The Institution of Naval Architects was a mere six years old. The Institution of Mechanical Engineers had its home still in Birmingham, and did not move to London for another 11 years; in 1866, Whitworth was president, and William P. Marshall was secretary. The president of the Institution of Civil Engineers was Sir John Fowler,

and James Forrest was the secretary; but Charles Manby was still associated with the Institution as honorary secretary. The Institution of Engineers and Shipbuilders in Scotland had been formed in 1865 by the amalgamation of the Scottish Shipbuilders' Association and the Institution of Engineers in Scotland. The latter society owed much of its standing to that great teacher of engineering subjects, W. J. M. Rankine, professor of civil engineering and mechanics at the University of Glasgow.

This outline of the engineering situation of 1865-66 is manifestly incomplete, but it is impossible, in a short space, to do justice to the teeming activities of the profession and industry, in which so many pioneer figures, whose names now are legendary, stood at the peak of their achievements. Bessemer was 52 when ENGINEERING was founded; Armstrong, 55; Nasmyth, 57 (but he had been living in retirement for nine years); Scott Russell was the same age, and Whitworth, five years older. Fairbairn and Sir John Rennie (both past-presidents of the British Association, which was a prominent forum for engineers) were among the older members of the band, being, respectively, 76 and 71, but both had several years of good work still in front of them. It was to an experienced and critical public, most of whom knew good work and expected it, that Zerah Colburn distributed the modest leaflet which announced that "In January, 1866, will commence the publication of a large, first-class, illustrated weekly newspaper, entitled "ENGINEERING."

"Arrangements will be made," continued the announcement, "whereby the best theoretical and practical talent will be secured in nearly every branch of professional art and science; and it will be the aim to represent the actual interests and progress of civil and mechanical engineering. Railway construction, machinery, plant, and working, will form a prominent department; as will also the general class of works more strictly included within the term Civil Engineering—as Harbours, Docks, Piers, Canals, Bridges, Lighthouses, etc., etc. Steamship construction and navigation, and the Marine Engine, as, indeed, the Steam Engine and prime movers generally, will receive especial attention. Gas-works, Water-works, Sewage-works, and Works of Irrigation, will occupy ample space. . . . The iron manufacture, including the whole details of blast furnaces, puddling plant and machinery, rolling mills, hammers, etc., and the recent wonderful improvements in the conversion of iron into steel by the Bessemer and other processes, will have their share of attention. Manufacturing machinery and plant, agricultural machinery, engineers' tools, pumps, etc., etc., will also be largely and usefully treated of." At the end of the long list of subjects was laid down the guiding principle that "new processes and patented inventions, as such merely, will be noticed according to their apparent importance, but, as a rule, will give place to actually tested or executed works and inventions." Most of the contemporary technical publications being inclined to rely unduly on patent agencies for their editorial matter, the declaration of this principle and the subsequent adherence to it may be supposed to have had considerable influence on the success of the new venture. The prospectus concluded with the statement that the paper "will form a 16-page quarto, exclusive of advertisements, each page, inclusive of margin, measuring 14 inches by 10½ inches, in three columns of clear type. The paper and printing will be of superior quality; and the engraved illustrations on wood, to the extent of nearly one-and-a-half square feet, or, say about 200 square inches per number, will be of the highest character for accuracy and beauty. The price of ENGINEERING will be 4d. Weekly, Stamped 5d., or Yearly, post-free and inclusive of double numbers, £1 2s. 6d."

Zerah Colburn, at this time, was 33 years of age, and already had acquired an engineering and journalistic experience unusual in both variety and its degree of responsibility. Born in Saratoga, New York, and a nephew of Zerah Colburn, the famous "calculating boy," after whom he was named, he had worked as a farm boy and as a junior clerk in a cotton-ginning plant before seeking a wider scope in the manager's office on the Concord Railroad. He "commenced author" at the early age of 15 with a series of pamphlets entitled *Monthly Mechanical Letters*, and, at the age of 19, became a regular contributor to the *American Railway Times*, a Boston publication. He had left the Concord Railroad for Boston, to enter Souther's locomotive works, and, while still in his 'teens, started another works, in partnership with Souther, to build locomotives. In 1853, he migrated to New York to become editor, on the mechanical side, of *The American Railroad Journal*. This appointment, however, lasted for less than a year, for, in November, 1853, he launched a new weekly publication, *The Railroad Advocate*, which he sold, in March, 1856, to Alexander L. Holley, then a draughtsman at the New Jersey Locomotive Works, and subsequently the American editorial representative of ENGINEERING. Colburn's next venture was a purchase of land in Iowa, where he had some notion of starting a saw mill, but, returning to New York to buy machinery for it, he succumbed to the more vivid life of a big city, and resumed writing for the *Advocate*. For a few months, he then took an agency for the Ames railway tyre, but gave this up in 1857 in order to pay a three months' visit to Europe. Returning to New York, he bought back a half share in the *Advocate* and changed its name to *The American Engineer*; a change which it survived for only a short time. In the autumn of 1857 he crossed the Atlantic once more, this time in company with Holley, having been commissioned by the presidents of several leading American railways to report on the current European practice in railway operation. The report was eventually published in book form.

Part of 1858 Colburn spent as superintendent of the New Jersey Locomotive Works at Paterson, but, before the year was out, he was back in England as editor of our contemporary, *The Engineer*, which had been founded in 1856. He returned to America in 1860 as a passenger on the first voyage of the Great Eastern and, in August of that year, started yet another journal, in Philadelphia, calling this also *The Engineer*. After a few issues, he abandoned it and came back to London in January, 1861, to resume the editorship of the English *Engineer*, which he retained until the autumn of 1864—an unusually long spell for Colburn; he then resigned his post, though remaining a contributor until the summer of 1865, and proceeded to set on foot his project of starting ENGINEERING. In this he had the assistance of the two very able young men, William Henry Maw and James Dredge, whose acquaintance he had made some time previously in connection with his earlier literary work. Maw was only 27, but for six years he had been head draughtsman in the locomotive and engineering department at the Stratford works of the then Eastern Counties Railway (subsequently the Great Eastern Railway). There he had met Colburn on one of the latter's visits in search of information, and had been asked to write the section on valve gears for Colburn's book on the locomotives exhibited at the 1862 Exhibition. Incidentally, in in executing this commission, Maw made the acquaintance of Bessemer; a fortunate circumstance for both, as Bessemer was able to give influential support to the new venture, while it was through Alexander Holley that the Bessemer process was introduced so successfully into the United States between 1867 and 1870.

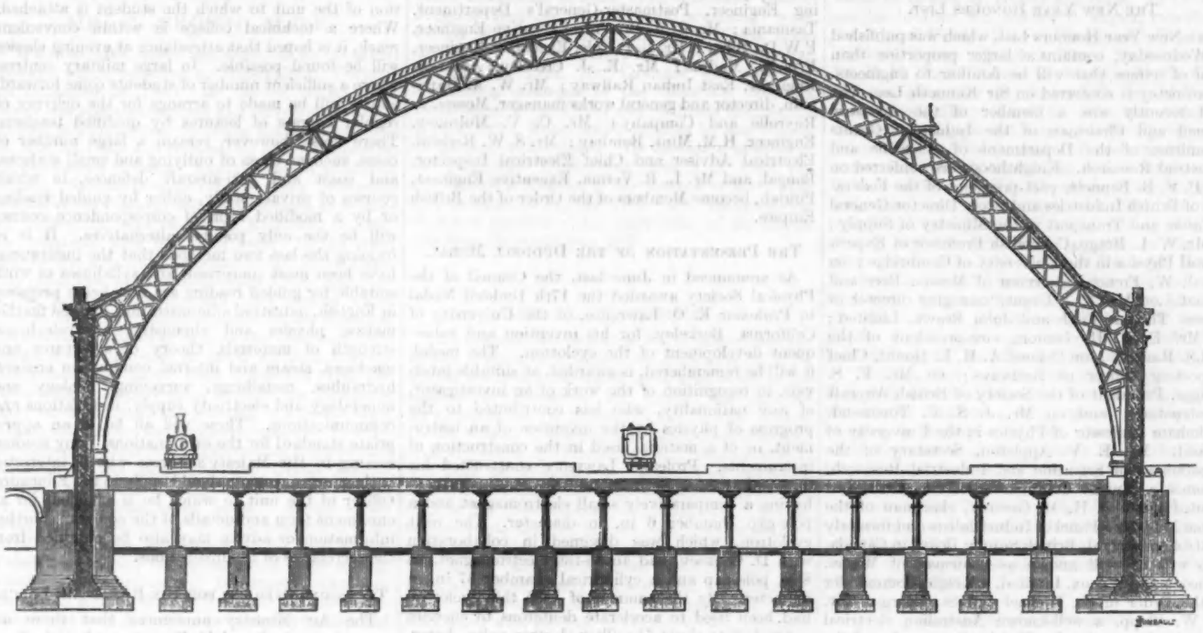
While Colburn, as proprietor and editor, exercised a general direction over the early policy of ENGINEERING, and Maw's duties were those of sub-editor, Dredge's concern was with the illustrations. He, too, was quite young—only 26—and had been engaged in the office of D. K. Clark, preparing drawings for Clark's *Locomotive Engineering*, when he attracted the attention of Colburn, who had undertaken to contribute the chapters on American locomotive practice. In 1862, Dredge left Clark's service, to enter that of Sir John Fowler, who was then consultant on the construction of the Metropolitan District Railway, and remained with Fowler until invited by Colburn to join the staff of his projected paper. It will be seen, therefore, that, young as the three men were, they could muster between them an engineering experience of considerable variety. The subdivision of functions, outlined above, continued for about three years; but Colburn, as always, proved to be a difficult person with whom to collaborate, and, at the end of February, 1870, he was persuaded to relinquish the proprietorship to Mr. Alexander T. Hollingsworth, who married, in that year, a niece of Sir Henry Bessemer. Apparently, it was Bessemer's suggestion that Mr. Hollingsworth—although he was, at the time, only 23 years of age—should acquire Colburn's interest in the paper. Colburn went to Paris, and thence to America, where he committed suicide on April 26 of the same year. Both physically and mentally he was exceptional, possessing immense energy, a superlative memory, and, incidentally, the unusual equipment of six digits on each hand and six toes on each foot; but, in the words of his obituary notice (almost certainly written by Maw), he "went to greater extremes both in work and relaxation than most men, and his irregularities were attended with melancholy results."

The collaboration of Maw, Dredge and Hollingsworth was a most happy one and soon developed into a partnership. Ultimately, in 1891, the business was formed into a limited liability company. The careers of all three were so fully detailed in their obituary notices that there is not the same occasion to summarise them here as there was in the case of Colburn. It may be mentioned, however, that Dr. Maw (who received the degree of LL.D., *honoris causa*, from the University of Glasgow in 1909) was president of the Institution of Mechanical Engineers in 1901-2, and of the Institution of Civil Engineers in 1922. He was a keen amateur astronomer, and occupied the presidential chair of the Royal Astronomical Society from 1905 to 1907. He was also a member of the General Board of the National Physical Laboratory from 1901 to 1915, and a member of the committee which inaugurated the British Engineering Standards Association. As a young man, he had been instrumental in founding, in 1859, the Civil and Mechanical Engineers' Society, a body which was formed with objects generally similar to those of the present Junior Institution of Engineers. It was subsequently amalgamated with the Society of Engineers. From 1863 to 1865, Maw was president of the Civil and Mechanical Engineers' Society, and was able to claim, therefore, in his old age, the unusual distinction that 59 years had elapsed between the tenure of his first presidency and his last.

James Dredge's great interest, outside of his editorial work, was in exhibitions, and he was intimately concerned with most of the notable events of this kind in the 30 years that followed his work of describing for ENGINEERING the exhibits at the Vienna Exhibition of 1873. He was similarly responsible for our accounts of the Centennial Exhibition of 1876 at Philadelphia and the Paris Exhibitions of 1878 and 1889. He was a member of the Royal British Commission for the Chicago Exhibition of 1893 and the Antwerp Exhibition of the following year; Commissioner-General for Great Britain at the Brussels Exhibition of 1897, and a vice-president of the British Commission for the Milan Exhibition of 1906. For his work in connection with the Paris Exhibition of 1889, he was made *Officier* of the Legion of Honour; and his services at the Brussels Exhibition of 1897 were recognised by the award of the C.M.G. He was a member of the Institutions of Civil and Mechanical Engineers and an honorary member of the American Society of Mechanical Engineers. It was at Dredge's suggestion that the publication was commenced of a monthly supplementary journal (sold separately from ENGINEERING) called *Traction and Transmission*. It appeared first in 1901, and was designed to contain articles of a more narrowly specialised character, for which space could not be found in the parent journal. Its continuance was considerably handicapped when, in 1903, Mr. Dredge suffered an attack of paralysis, as he was solely responsible for its editorial direction. On his partial recovery, he endeavoured to persevere with the editorship; but he found the strain too much, and, in 1904, *Traction and Transmission* ceased to appear.

When Dredge died, in 1906, his place as joint editor was filled by the appointment of Mr. B.

ROOF OF THE SAINT PANCRAS STATION—MIDLAND RAILWAY.



Alfred Raworth, Wh.Sc., who had been personal assistant to Sir Joseph Whitworth and subsequently chief technical assistant to Sir Lloyd Wise before he joined the staff of ENGINEERING in 1882. Raworth died in 1919 and was succeeded by Mr. (afterwards Sir) Alexander Richardson, who had been on the staff since 1890, and who was, for a time, sole editor after the death of Dr. Maw in 1924. Mr. Hollingsworth survived his old partner only four years. The proprietorship is still in the hands of his descendants.

No account of the personalities associated with ENGINEERING could afford to ignore that unique and lovable character, the late H. M. Martin; though it is a hopeless task to attempt to enumerate all the admirable contributions which he made to our columns, many of them the fruits of extensive original research, which definitely advanced current knowledge of their varied subjects. Martin was a Whitworth Scholar of 1885, who subsequently studied under Unwin at the City and Guilds Institute, and it was on Unwin's recommendation that Dr. Maw engaged him in July, 1887. In 1891, there appeared his study of "The Strength of Short Boilers," the first of a long series of special articles. He had previously contributed a paper on "Arched Ribs and Voussoir Arches" to the *Proceedings* of the Institution of Civil Engineers, which was awarded a Miller Prize, but the paper on boilers really marks the beginning of his series of critical engineering studies. In civil engineering, they included statically indeterminate structures, masonry dams, and suspension bridges; in mechanical engineering, the principles of steam-turbine design, and their practical application, the strength of rotating discs, the theory of the surface condenser, and the theory of lubrication, with particular reference to the Michell bearing. In the field of applied physics, he dealt with the kinetic theory of gases, the laws of heat transfer and the properties of steam; and, in aerodynamics, he did much to direct attention to the theory of aeroplane lift and drag enunciated by Lanchester and developed by Prandtl. He was an original member of the Sub-Committee on Lubrication and Lubricants in 1917, and of the Steam Nozzles Research Committee of the Institution of Mechanical Engineers, established in 1914. The work of this committee was largely on the lines suggested by Martin's articles on the subject of nozzle experiments, which appeared in 1913; and the apparatus used was designed by him. Several of his series were reprinted, and much of his work on turbine design was collected in a book, *The Design and Construction of Steam Turbines*, which appeared in 1913. His death, in 1933, was generally deplored as a loss to engineering.

From the personalities of those who established and built up the reputation which ENGINEERING has enjoyed for so many years, we may now turn to a few representative references to the paper itself. The descriptive articles which appeared in the first issue included one on "H.M. Ironclad Frigate Bellerophon," and another on "The Mont Cenis Railway." There were three lengthy book reviews, dealing, in this order, with Scott Russell's monumental work, *The Modern System of Naval Architecture*, Sir (then Mr.) William Fairbairn's *Treatise on Iron Shipbuilding*, and Henry Dircks's *Life, Times and Scientific Labours of Edward Somerset, Second Marquis of Worcester*. On page 12, there appeared an illustrated description of the roof of St. Pancras station, as designed by Mr. H. Barlow, F.R.S., the engineer to the Midland Railway. A reproduction of this woodcut is given herewith, by way of contrast with the modern practice of ENGINEERING in the presentation of line illustrations: a feature which, we may claim with confidence, is excelled in quality by no other technical journal in the world. It is particularly interesting to observe, in this issue of January 5, 1866, the advertisements of many firms whose names (not always the same names, however) are household words among engineers to-day. Among them may be mentioned Naylor, Vickers and Company, of Sheffield (now part of the English Steel Corporation); Hayward Tyler and Company, now of Luton, but then in London; Clayton, Shuttleworth and Company, Lincoln; Bryan Donkin and Company, now of Chesterfield, but then still in Bermondsey; Ransomes and Sims (now Ransomes, Sims and Jefferies); Gwynne and Company, then of Essex-street Works, Strand; Thomas Robinson and Son, of Rochdale; Tangye Brothers and Price; Lloyd and Lloyd (now Stewarts and Lloyds); and Aveling and Porter (now amalgamated with Barford and Perkins as Aveling-Barford, Limited). Many others, however, such as Henry Bessemer and Company, and, more recently, John Musgrave and Sons, of Bolton, have been less fortunate, and their names have now only a historical significance.

An innovation which made its appearance in the issue of January 31, 1868, was a folding plate printed in no less than ten colours. This illustrated a railway coach built for the Tsar of Russia at the Alexandroffski Works of Messrs. Winans, Harrison and Winans, to the order of the Nicolai Railway. It was a creditable production, and the colours are still vivid in our file copy.

One of the first series of special articles appeared in 1867 and dealt with "Long Span Railway Bridges." The modest signature "B.B." was that of the eventual designer of the Forth Bridge, Sir Benjamin Baker. In view of the connection established so early in Baker's career (he was 27 when the articles were published), it is not surprising that a particularly full account of the Forth Bridge subsequently appeared in our columns, and was reprinted as a separate publication. This was but one of many reprints of outstanding series of descriptive articles. Among them may be mentioned the special issue, in 1893, which contained descriptions of the new Cunarders Campania and Lucania, as well as a long account of the Chicago World's Fair; the Manchester Ship Canal (1891); the erection on the Embankment of the Cleopatra Needle (this reprint was a copy of the memorial deposited under the Needle on September 12, 1878); and the descriptions of the Mauretania, Aquitania, and, most recent of all, of the Queen Mary.

Naval affairs have always found a place in ENGINEERING, which has attracted many articles and letters from naval officers. Examples are the series on the effect of steam propulsion on naval tactics, by "The Captain of a Battleship," afterwards revealed to be Admiral C. C. P. Fitzgerald; and the long agitation for the conferment on naval engineers of a status more in accord with their responsibilities, to which the late G. R. Dunell (1847—1907) applied his powerful advocacy with marked effect. More recent series of articles which have attracted attention by their wealth of technical detail have been the descriptions of the Trenton Channel power station (1928), the Welland Canal (1930), and the Boulder Dam (1937).

Space does not permit the selection of any further landmarks in the 75 years' history of ENGINEERING, but these notes will serve, perhaps, to justify the claim that the high principles which were enunciated by its founder have been kept constantly in mind as they are to this day. As an assurance for the future, we cannot do better than repeat that of Zerah Colburn, in the introductory article in the first issue, that ENGINEERING "will strive to collect and present the greatest amount of engineering news, and it will discuss honestly and earnestly everything likely to advance engineering practice."

NOTES.

THE NEW YEAR HONOURS LIST.

THE New Year Honours List, which was published on Wednesday, contains a larger proportion than usual of names that will be familiar to engineers. A baronetcy is conferred on Sir Kenneth Lee, who until recently was a member of the Advisory Council and Chairman of the Industrial Grants Committee of the Department of Scientific and Industrial Research. Knighthoods are conferred on Mr. P. F. B. Bennett, past-president of the Federation of British Industries and lately Director-General of Tanks and Transport in the Ministry of Supply; on Mr. W. L. Bragg, Cavendish Professor of Experimental Physics in the University of Cambridge; on Mr. J. W. French, chairman of Messrs. Barr and Stroud; on Mr. A. J. Grant, managing director of Messrs. Thomas Firth and John Brown, Limited; on Mr. E. J. H. Lemon, vice-president of the L.M.S. Railway; on Colonel A. H. L. Mount, Chief Inspecting Officer of Railways; on Mr. F. S. Spriggs, President of the Society of British Aircraft Constructors; and on Mr. J. S. E. Townsend, Wykeham Professor of Physics in the University of Oxford. Mr. E. V. Appleton, Secretary of the Department of Scientific and Industrial Research, becomes a Knight Commander of the Bath, and Lieut.-Colonel J. H. M. Greenly, chairman of the Prime Minister's Panel of Industrialists and formerly Controller-General, British Supply Board in Canada, who will be well known as chairman of Messrs. Babcock and Wilcox, Limited, a Knight Commander of the Order of St. Michael and St. George. Mr. H. W. Clapp, a well-known Australian electrical engineer, is appointed a Knight Commander of the Order of the British Empire. Engineer Rear-Admiral M. G. A. Edwards; Mr. E. Holloway, Director of Works, Air Ministry; Mr. J. S. Pringle, Director of Electrical Engineering, Admiralty, and Mr. R. A. Watson Watt, Scientific Adviser on Telecommunications, are appointed Commanders of the Bath. Mr. D. J. Blomfield, Chief Engineer, Communications and Works Department, Bengal; Major T. F. Borwick, Director of Ordnance Factories, India; Mr. J. A. R. Bromage, Superintending Engineer, Delhi; Mr. F. M. Dowley, Chief Engineer for Irrigation, Madras; Mr. F. A. Farquharson, Chief Engineer, P.W.D., Punjab; Mr. A. Oram, Chief Engineer, P.W.D., North-West Frontier; and Mr. A. S. Trollip, general manager, Bombay Electric Supply and Tramways, become Companions of the Order of the Indian Empire. Mr. G. E. Bailey, managing director, Metropolitan-Vickers Electrical Company; Mr. S. Camm, chief designer, Hawker Aircraft Company; Mr. A. G. Elliott, Chief Engineer (Aero Division), Rolls Royce, Limited; Mr. R. T. G. French, Secretary of the Electricity Commissioners; Mr. S. E. Garcke, vice-chairman, Tilling and British Automobile Traction Company; Mr. W. E. Hogg, Chief Engineer (Inspection), Crown Agents for the Colonies; Engineer Rear-Admiral A. E. Hurst; Mr. T. McKenzie, general manager, Metal Industries, Limited; Mr. H. J. B. Manzoni, City Engineer and Surveyor, Birmingham; Mr. E. D. Meryon, Director of Contract Work, Admiralty; Mr. N. Rowbotham, works manager, Bristol Aeroplane Company; Mr. C. E. Walker, Director of Materials Production, Ministry of Aircraft Production; and Mr. J. Webb, Inspector-General of Telegraphs and Telephones, Egyptian Government, are appointed Commanders of the Order of the British Empire. The distinction of O.B.E. has been conferred upon Engineer-Captain E. J. Bedwell; Mr. E. H. Ford, City Engineer and Surveyor of Coventry; Mr. G. S. Hallas, Chief Engineer, Air Ministry; Mr. H. R. Harbottle, Assistant Staff Engineer, General Post Office; Mr. C. Hollyoak, Superintendent, Royal Ordnance Factory, Nottingham; Mr. H. T. Johnson, Principal Ship Overseer, Admiralty; Mr. G. F. Masters, Superintendent, Royal Gun and Carriage Factory, Woolwich; Mr. J. W. Mills, Deputy Director of Armament Production, Ministry of Aircraft Production; Mr. P. H. Muirhead, Director and Works Manager, Messrs. Vickers-Armstrongs, Limited, Newcastle-upon-Tyne; Mr. R. K. Pierson, chief designer, Vickers and Supermarine; Mr. R. O. C. Thomson, Executive Engineer, North-Western Railway, Quetta; Mr. H. M. Webb, City Engineer, Bristol. Mr. J. Aspinall, works director, Messrs. Hick, Hargreaves and Company; Mr. G. J. Braithwaite, Superintending Engineer, Postmaster-General's Department, Tasmania; Mr. C. A. Browne, Executive Engineer, P.W.D., Bihar; Mr. L. P. Cole, Executive Engineer, P.W.D., Madras; Mr. E. J. Crossley, Assistant Engineer, East Indian Railway; Mr. W. A. Harriman, director and general works manager, Messrs. A. Reyrolle and Company; Mr. C. V. Mulroney, Engineer, H.M. Mint, Bombay; Mr. S. W. Redcliff, Electrical Adviser and Chief Electrical Inspector, Bengal, and Mr. L. B. Verma, Executive Engineer, Punjab, become Members of the Order of the British Empire.

THE PRESENTATION OF THE DUDDELL MEDAL.

As announced in June last, the Council of the Physical Society awarded the 17th Duddell Medal to Professor E. O. Lawrence, of the University of California, Berkeley, for his invention and subsequent development of the cyclotron. The medal, it will be remembered, is awarded, at suitable intervals, in recognition of the work of an investigator, of any nationality, who has contributed to the progress of physics by the invention of an instrument, or of a material used in the construction of instruments. Professor Lawrence constructed his first cyclotron, at Berkeley, in 1930, this instrument having a comparatively small electromagnet and a pole-gap chamber 6 in. in diameter. The next cyclotron, which was designed in collaboration with D. Cooksey, had an 85-ton electromagnet, an 8-in. pole-gap and a cylindrical chamber 37 in. in diameter. By the summer of 1935 this cyclotron had been used to accelerate deuterons to energies equivalent to about 5½ million electron volts. Later, deuterons with energies of 8 million electron volts and α-particles of 16 million electron volts were produced and used as projectiles for the production of large yields of neutrons from beryllium; artificial radioactive elements, such as radio-sodium, were also produced. More recently, a new 60-in. cyclotron with a 220-ton magnet, constructed mainly for biological and clinical investigations, has been installed in the Crocker Radiation Laboratory at Berkeley, and with it deuterons having energies of about 18 million electron volts have been obtained. The latest stage in the development of Professor Lawrence's invention will be reached when the 4,900-ton, 184-in. cyclotron, the construction of which is to be financed by the Rockefellow Foundation, has been completed. With this apparatus it is hoped to accelerate deuterons to energies of the order of 100 million electron volts, and some important developments in atomic physics and its applications may be anticipated. The announcement of the award of the Medal to Professor Lawrence evoked great interest and satisfaction among physicists on both sides of the Atlantic. The late Lord Lothian had agreed to make the presentation at Philadelphia on December 27, but it was actually made by Mr. Neville Butler, First Counsellor to the British Embassy and H.M. Chargé d'Affaires *ad interim*, at a dinner held in connection with a meeting of the American Physical Society.

VOCATIONAL INSTRUCTION FOR THE FORCES.

One of the effects of the last war was to bring about a break in the studies of a whole generation of engineers, with consequent loss to the profession. Individuals, in particular, were hampered by the difficulty of resuming their studies and of passing their examinations, and were consequently handicapped. We are, therefore, glad to learn that this time the Institutions of Civil, Mechanical and Electrical Engineers are co-operating with the Board of Education and the Advisory Council for Education in the Forces in the organisation of courses in engineering subjects for those who wish to continue their studies while temporarily serving in His Majesty's Forces. The provision of such courses of engineering study will, it is felt, not only provide useful mental occupation, especially during the winter months, should the conditions of war allow a measure of study, but will also help those whose engineering training has been interrupted by the war to keep in touch with technical knowledge and perhaps, in some cases, to complete a portion of their engineering qualifications while still serving. There are four methods by which such vocational instruction can be given, depending on the size and location of the unit to which the student is attached. Where a technical college is within convenient reach, it is hoped that attendance at evening classes will be found possible. In large military centres, where a sufficient number of students come forward, efforts will be made to arrange for the delivery of regular courses of lectures by qualified teachers. There must, however, remain a large number of cases, such as those of outlying and small stations, and coast and anti-aircraft defences, in which courses of private study, either by guided reading or by a modified form of correspondence course, will be the only possible alternatives. It is in framing the last two methods that the institutions have been most concerned, and syllabuses of work suitable for guided reading are now being prepared in English, industrial administration, applied mathematics, physics and chemistry, electrotechnics, strength of materials, theory of structures and machines, steam and internal combustion engines, hydraulics, metallurgy, surveying, geology and mineralogy and electricity supply, installations and communications. These will all be of an appropriate standard for the examinations. Any student serving in His Majesty's Forces who is interested in these arrangements should apply to the Education Officer of the unit to which he is attached for an enrolment form and details of the courses. Further information or advice may also be obtained from the secretaries of the institutions.

TECHNICAL OFFICERS FOR THE ROYAL AIR FORCE.

The Air Ministry announces that there are vacancies in the Royal Air Force for technical officers who will be employed on engineering, armament and signals duties. The minimum qualification required from candidates in the first group is that they shall be holders of mechanical engineering degrees or mechanical engineering certificates. Alternatively, they must be mechanical engineer members of engineering institutions who have also had two years' practical experience or be practical engineers who have served an apprenticeship followed by a number of years' experience in erecting or overhauling internal-combustion engines or aeroplane structures, and with knowledge of the properties of engineering materials. Armament officers must also be holders of engineering degrees or engineering certificates or be members of engineering institutions with at least two years' practical experience in particularly armament manufacture. Alternatively, practical engineers who have served an apprenticeship followed by a number of years' practical engineering experience and with knowledge of the properties of engineering materials will be considered. To obtain admission to the signals group, candidates must be holders of electrical engineering or science degrees with experience of wireless or be holders of technical college or approved institution diplomas and have two years' experience in telecommunications engineering, preferably on the radio side. A number of posts is also available for candidates possessing a sound theoretical knowledge of elementary electricity and magnetism, of the principles of wireless telegraphic and telephonic communications and of transmitter circuits, modern wireless receiving apparatus and apparatus for the measurement of high-frequency potentials and currents. Some practical experience in addition is desirable and specialised knowledge in one or more of the practical aspects of telecommunication would be an asset. Commissions in the Royal Air Force Volunteer Reserve will be granted for the duration of hostilities to suitable applicants between the ages of 21 and 50 years, possessing the requisite personal and technical qualifications. Candidates should apply in writing to the Air Ministry, S.7(*e*)1, Adastral House, Kingsway, London, W.C.2, giving full particulars of their qualifications, training and experience. Those who are engaged on the production of aircraft, engines, or accessories, or on other important national work, should not submit applications without first consulting their employers as to the possibility of their being spared for duty. Candidates who have previously applied are requested not to renew their applications.

OBITUARY.

MR. C. BROWN, M.B.E.

WE note with regret the death of Mr. Cuthbert Brown, which occurred at Wolsingham, Durham, on December 24, 1940. Mr. Brown, whose entire career was spent as engineer and surveyor to various district and municipal councils in England, was born on May 15, 1863, and received his general education at Robinson's Academy and the Royal Grammar School, Newcastle-upon-Tyne. After attending courses at the Durham College of Science, he became an engineering pupil of Mr. A. M. Fowler in 1881, and remained with him until 1885. In the latter year he was appointed assistant to Mr. W. G. Laws, City Engineer of Newcastle-upon-Tyne, and continued in this capacity until 1897, during which time he acted as resident engineer on the Spen and Derwenthaugh Railway and on the Ouseburn main outfall sewer. He also prepared working drawings and carried out other work connected with the Pandon Dene Improvement Scheme, the Newcastle Quay extension, and the building of a cattle sanatorium, fish market and municipal stables. In 1897, Mr. Brown was appointed Waterworks Engineer and Surveyor to the Bedlingtonshire Urban District Council, Northumberland, and held this position for the succeeding seven years. Among other works he was responsible for the construction of an outfall sewer from Bedlington to the tidal waters of the River Blyth; the laying out of a new sewage system for Choppington, Bedlington, Cambois, Netherton and Sleekburn Village; and the construction of sand filters, a new pumping station and a series of retaining walls.

From 1904 until 1911 Mr. Brown was Borough Engineer and Town Surveyor to the Corporation of Chelmsford, Essex. During this period of his career he was responsible for the design and construction of concrete storage reservoirs, the laying of pumping mains and the erection of a large open-air swimming bath. Mr. Brown was made Engineer and Surveyor to the Edmonton Urban District Council, Middlesex, in 1911, and continued in this capacity until his retirement some time ago. He remodelled the sewage works, abandoning land treatment in favour of bacteriological methods; widened a main highway by culverting-in the Pymmes Brook; and prepared plans, estimates, etc., for the laying out of all roads and sewers for 1,765 houses, built under the Assisted Housing Scheme. During the war of 1914-18, he designed and constructed pumping engines for the Ministry of Munitions for Eley's Factory, and, for this and other services of a similar nature, received the M.B.E. He was elected an associate member of the Institution of Civil Engineers in 1901, and was transferred to the class of member in 1923.

MR. W. S. EDWARDS.

Mr. Wodehouse Samuel Edwards, whose death, we regret to have to record, took place at Bexley, Kent, on December 26, 1940, was born at Blaisdon, Glos., on January 2, 1879. For the past 20 years he had been engineering manager, Materials Handling Department, Fraser and Chalmers Engineering Works, Erith, Kent. After receiving his general education at the establishment of the Rev. Basil Edward, M.A., Ashleworth Rectory, Gloucester, he entered upon a pupilage of five years in the works of Messrs. William Sisson and Company, engineers, Gloucester, in September, 1896, meanwhile continuing his technical education by attending courses in machine drawing and design, physics and chemistry at evening centres in Gloucester. On the conclusion of his apprenticeship, in 1901, he was placed in charge of outside erection work for Messrs. Sisson and Company, but in the succeeding year joined the staff of Messrs. Spencer and Company, Limited, Melksham, Wilts., as assistant engineer on the construction and fabrication of new works. Subsequently, he was appointed assistant works engineer, and, later, chief electrical engineer of the firm. Mr. Edwards, however, relinquished this position in September, 1911, on appointment as chief contract engineer on the staff of Messrs. Willans and Robinson, Limited, Rugby. After occupying this position for five years, he became, in June, 1916, Admiralty District Progress Engineer, for all naval armament work, for the Midland Counties and South Wales, under the late Sir Vincent Raven, K.B.E. After the war, on April 1, 1919, Mr. Edwards was appointed engineering manager of the Materials Handling Department at the Fraser and Chalmers Engineering Works, Erith, Kent, which position he was holding at the time of his death. He became a member of the Gloucester Engineering Society in 1898, and was elected a Member of the Council of the Rugby Engineering Society in 1916. Mr. Edwards was elected a member of the Institution of Mechanical Engineers so recently as 1939.

MR. A. T. COODE.

The news of the death of Mr. Arthur Trevenen Coode, of Hazlemere, Bucks, on December 28, 1940, will be received with regret by a wide circle in the engineering profession. Mr. Coode, who had for many years been a partner in the firm of Messrs. Coode, Wilson, Mitchell and Vaughan-Lee, chartered civil engineers, 9, Victoria-street, London, S.W.1, was born on February 5, 1876. After attending Fauconberg School, Beccles, Suffolk, he entered the engineering laboratories at University College, Gower-street, London, in 1893, and, two years later, went up to the Engineering School at Cambridge University. Mr. Coode gained the B.A. degree in 1898, and subsequently entered upon a pupilage of three years under Mr. J. Mansergh. His long association with the firm of Coode, Wilson, Mitchell and Vaughan-Lee commenced in 1902, when he began work in the London office of the firm, then known as Coode, Son and Matthews. His first appointment was that of marine engineering assistant to Mr. H. T. Ker, resident engineer on the Folkestone Pier extension works. In the following year he was made assistant engineer on the Folkestone Harbour extension works. Briefly, these comprised the lengthening of the old pier by 900 ft., the widening and strengthening of the older portion, on both faces, and the arrangement and laying out of the superstructure and surface of both the old and the new work, to deal with the cross-channel traffic of the port.

In 1905 he was engaged on operations connected with the Plymouth sewerage outfall works and on the examination of sites for a harbour of refuge on the north coasts of Devon and Cornwall. Mr. Coode became a partner in the firm of Coode, Son and Matthews in 1906, and was subsequently jointly responsible for many marine works. These included the construction of long breakwaters at Accra and Sekondi Harbours on the Gold Coast; the improvement of the entrance to Lagos Harbour, Southern Nigeria, by the erection of rubble training moles and screw-pile wharves and dredging; and the construction of a 450-ft. screw-pile jetty and 250-ft. mass-concrete sheltering arm at Larnaca Harbour, Cyprus. Mr. Coode was also concerned with the erection of slipways at Calabar and Forcados, Southern Nigeria; repairs to wharf walls at Freetown, Sierra Leone, and the preparation of designs for various public works at Gambia, West Africa; Singapore; Bridgetown, Barbados; and Port of Spain, Trinidad. After serving with the Forces during the war of 1914-18, he returned to his firm in Victoria-street and continued to take an active part in the marine and other civil engineering works undertaken by the partners. Mr. Coode was elected an associate member of the Institution of Civil Engineers in 1902, and became a full member in 1912.

MR. H. M. NAPIER.

Mr. Henry Melvill Napier, the veteran Clyde shipbuilder, died at his home, Milton House, Bowling, Dumbartonshire, on December 18, 1940. He was the son of the late Mr. James R. Napier, F.R.S., and a grandson of Robert Napier, the celebrated pioneer of modern shipbuilding on the Clyde, and was born on May 2, 1854. He was educated at the Glasgow High School and at the University of Glasgow, and subsequently served an apprenticeship of six years in the shipyard and marine engineering works of Messrs. R. Napier and Sons. In 1877, he and his brother, Mr. Robert T. Napier, established the firm of Messrs. Napier, Shanks and Bell, shipbuilders, Yoker, Glasgow. Some 20 years later, Mr. H. M. Napier became associated with Mr. G. M. Miller, and together they founded the firm of Messrs. Napier and Miller, Limited. The new company acquired the shipyard at Yoker, previously owned by Messrs. Napier, Shanks and Bell, and immediately began shipbuilding operations on a large scale. Between 1898 and 1906, 66 vessels of various sizes and types were constructed. In 1906, the firm transferred its activities to a new site at Old Kilpatrick, and the first vessel launched in the new yard was the s.s. Irish Monarch, built for Messrs. Raeburn and Verel, Limited, Glasgow, the managers of Messrs. Monarch Steamship Company, Limited, for whom Messrs. Napier and Miller built several ships. Some years ago, however, the Old Kilpatrick Shipyard was closed down and was acquired by National Shipbuilders Security, Limited. Although he described himself as a retired shipbuilder, Mr. Napier retained a deep interest in ships and shipping to the end of his life. He was a member of the Committee of Management and of the Technical Committee of the British Corporation Register of Shipping and Aircraft, and was also for many years one of the Trustees of the Clyde Navigation. He had been a member of the Institution of Engineers and Shipbuilders in Scotland since 1881, and was elected a member of the Institution of Naval Architects in 1887.

ENGINEERING CENTENARIES IN 1941.

AMONG the most interesting centenaries of 1941 is that of the Italian physicist Antonio Pacinotti, who, as a youth still in his 'teens, serving in the Garibaldean war of 1859, pondered over electromagnetic problems and devised the dynamo with the ring-armature. Like his father, he was a professor of physics at Pisa, and, on May 24, 1934, when the Italians celebrated the anniversary of their entrance into the Great War on the side of the Allies, the day was marked, by desire of Signor Mussolini, by the commemoration of the 75th anniversary of Pacinotti's invention. It was on this occasion that Marconi was made Hon. D.Sc. of Pisa University. Pacinotti died at Pisa in 1912. Ten years previously he had been elected an honorary member of the Institution of Electrical Engineers.

A physicist of even greater distinction, born in 1841, was Marie-Alfred Cornu, who, after a brilliant career as a student at the Ecole Polytechnique and the Ecole des Mines, in Paris, at the age of 26, was made a professor at the former school, holding this post for thirty-five years. A worthy successor of Arago, Biot, Fresnel and Fizeau, he did fine work in optics and was especially known for his re-determination of the velocity of light. In 1896, he was elected President of the Paris Academy of Sciences. Some of his memoirs dealt with electrostatics, and in these he explained the "potential" theories of Gauss and George Green, then little known in France. Green died in June, 1841, just two months after Cornu was born. The son of a miller of Nottinghamshire, and born in 1793, Green was a self-taught mathematician. In 1828, he published, by subscription, his "Essay on the Application of Mathematical Analysis to the Theories of Electricity and Magnetism." This paper escaped the notice of mathematicians until 1846, when Kelvin had it reprinted. Another mathematician, well known to engineers, who died in 1841, was Olinthus Gilbert Gregory, who for many years held the chair of mathematics at the Royal Military Academy, Woolwich. He was an experimentalist, a writer of text-books, a promoter of the London University, and the father of Sir Charles Hutton Gregory, president of the Institution of Civil Engineers in 1867. Another promoter of the London University was Dr. George Birkbeck (1776-1841), the father of mechanics' institutes.

Trained as a doctor, in 1799 Birkbeck was made professor of natural philosophy in the Andersonian University, Glasgow, and in 1800 he advertised a class "solely for persons engaged in the exercise of the mechanical arts." It would be difficult to form a true idea of his influence. Birkbeck College is but one of the institutions which grew out of his pioneering activities.

Of engineers born in 1841 who attained distinction in one way or another we may recall George Wallace Melville (1841-1912), who held the high office of Engineer-in-Chief of the United States Navy during a period which saw the rise of America's modern fleet; John Donaldson (1841-99), the collaborator with Sir John Thornycroft at Chiswick; Dr. Andrew Common, F.R.S. (1841-1903), whose skill was largely devoted to the making of silvered-glass mirrors for telescopes; Theodor Peters (1841-1908), who for a generation devoted himself to the interests of German engineers and the activities of the Verein Deutscher Ingenieure; and Sir Clement Le Neve Foster (1841-1904), professor of mining at the Royal School of Mines and author of a notable work on "Ore and Stone Mining." The present year also marks the bicentenary of the birth of the versatile and ingenious Captain Joseph Huddart, F.R.S. (1741-1816), who designed sailing ships, surveyed the coasts of India and some of the ports and dockyards of Britain, was an Elder Brother of Trinity House, and made a fortune out of his rope-making machine, patented in 1799. Of events of 1841, of engineering interest, mention may be made of the opening of the whole lengths of railway between London and Bristol, and London and Brighton, and the tragic loss of the early transatlantic steamer President. In December, 1841, the great geodesist, Everest, as Surveyor-General of India, saw the completion of the measurement of an arc of meridian more than 21 deg. in length.

THE INSTITUTION OF GAS ENGINEERS.

THE usual autumn Research Meeting of the Institution of Gas Engineers was not held in 1940, but a number of reports and papers which would ordinarily have been submitted to that meeting have now been published. The occasion is noteworthy in that, for the first time, the research of the Institution is under the supervision of the newly-formed Gas Research Board. The first report of the Board refers to the fact, already made public, that, under the conditions now ruling, it has been decided not to appoint a Director of Research, but to ask the secretary of the Institution, Dr. W. T. K. Braunholtz, who is also the secretary of the Gas Research Board, to serve as acting Director of Research. The committees which have hitherto functioned as joint committees of the Institution of Gas Engineers and other bodies will now be termed Joint Committees of the Gas Research Board and other bodies. A bureau of information is to be established which seeks to co-operate with the private bureaux already established by some of the larger undertakings and firms. All members of the Board will receive, from time to time, confidential reports of the progress of investigations, but the researches will also form basic topics for the Annual Research Meeting of the Institution of Gas Engineers, at which the work done under the Board will be submitted for discussion. Inevitably, the work of the Board has been coloured by the necessity of mobilising every resource for war purposes and, for this reason, it has not been as constructive as could have been wished. The Council remark, however, that, although it is impossible, at the present time, to forecast what may be the position of the gas industry at the conclusion of the war, it appears certain that, with the reconstruction that will inevitably be necessary, the need for a reasoned fuel policy for the nation will be recognised. The position of the industry in this scheme must be important, and, obviously, if the nation finds that it is unable to import to the same extent as in the past, it must rely more on goods which can be produced at home. Problems will then arise of the type upon which the long-distance programme of the Gas Research Board must be framed. Such fundamental issues have not been forgotten, even though the urgent demands of the past few months have made it impossible to foresee the future for more than a short time ahead.

The work conducted by the Joint Research Committee of the Gas Research Board and Leeds University has been directed, of late years, to the production of gas of the normal calorific value required for town purposes by the total gasification of coal, utilising a process of carbonisation under pressure in the presence of hydrogen for the enrichment of this gas by methane. This work has been continued, but with special reference to the production of methane, which it was thought might be required for motor traction. Special attention has been paid to the possibility of devising a process which could be put into operation quickly, should the demand for methane for this purpose exceed the available supplies. Although it is not considered to be in the national interest to publish detailed results of the investigations at the present time, it may be said that the difficulties which had hitherto hindered the development of this process are becoming far more clearly understood and controllable. The well-known difficulties of the catalytic process are the deposition of carbon on the catalyst, the progressive loss of activity in the catalyst, due to "ageing," and the poisoning of the catalyst by sulphur compounds. Each of these problems has been attacked with considerable success by the chemists engaged on this work, and they no longer appear as such formidable obstacles. At the same time, the strongly exothermic nature of the reaction tends to make the preparation of methane in this way a process of low thermal efficiency. It is probable that means will be found to employ this exothermic heat usefully, and in such a way that the overall thermal efficiency is not reduced; this aspect has received considerable attention. The production of methane by the gasification of coal in hydrogen under pressure has not lost its interest, but circumstances arising from the war have made it impossible, so far, to proceed with the large-scale experiments that had been planned in co-operation with the Fuel Research Board.

No experimental work is in progress on the combustion characteristics of town's gas, which have been the subject of reports in previous years. Many of the researches that have been started or planned have had to be suspended owing to war conditions, but such as have been continued are described in papers which will be summarised in later issues of ENGINEERING. A survey has been made of the carbonising plant available in the country for the production of specially reactive coke for use in portable gas producers, and of the methods to be adopted in operating horizontal retorts, and continuous or intermittent vertical retorts, to yield a satisfactory fuel. This work is still in progress, and developments from it may be of permanent interest after the end of the war.

The work done during the year is discussed in the first report of the Chairmen's Technical Committee. Research work proper is conducted by the Gas Research Board, while the technical activities of the Institution, other than the immediate control of research, continues to be directed by its Technical Committees dealing, respectively, with domestic heating, liquor effluents and ammonia, lighting, gas-works safety rules (including gas holders), pipes, and meters. The purpose of the Chairmen's Technical Committee, to which these committees are responsible and of which the chairman of each Technical Committee is a member, is to enable the work of these committees to be co-ordinated, and overlapping to be avoided. Separate reports are not being published this year by the Technical Committees, but some of the more important developments are briefly summarised below.

As a result of representations made by the Gas-Works Safety Rules Committee, the Home Office has agreed that, in sub-section 1 (*b*) of the Factories Act, 1937, an adequate seal of the self-sealing type would provide a satisfactory alternative to the normal type of safety valve, provided that the outlet from benzole stills is piped to a safe place outside the workroom; the outlet from ammonia stills must be in a safe place, but not necessarily outside. There should be no cock or valve between the seal and the still. In the examination of receivers, neither removal of lagging nor dismantling of the vessel at the bolted joints is normally necessary as a routine preparation for thorough examination at any regular intervals. The committee has been consulted by the Home Office regarding section 47, sub-section 2 (*b*) of the Act, concerning the removal of injurious fumes from stationary internal-combustion engines; and it has been agreed that, since the strict interpretation of the partitioning off of a gas engine may sometimes involve hardship, discretion may be exercised where the cost involved would be a considerable burden and the risk of leakage of injurious fumes into the workroom appears, from the construction and position of the engine, to be remote, if the firm can be relied upon, without further visits or warnings from the inspector, to secure a sufficiently high standard of maintenance to prevent such leakage arising from wear and tear or faulty use of the engine. When the engine is small and no one is employed near to it except for short periods, and the building is of such a size that a slight emission of fumes from the engine would not be detrimental to the health of the employees, a somewhat lower standard of maintenance may be considered reasonable. On new installations where the crankcase of the engine is totally enclosed, the Home Office will consider such total enclosure to be equivalent to partitioning off the engine, provided the crankcase breather is led by piping to the outside of the building, or is connected to the inlet manifold of the engine in such a manner that it is not possible for the fumes to escape into the workshop.

The same committee, having regard to the difficulties experienced during the very severe weather last winter, has sought particulars of all spirally-guided gas holders, with details of any accidents that had occurred. Small holders are more prone to freezing than large holders, because the rate of cooling is, roughly, inversely proportional to the diameter of the tank. Moreover, small holders are more liable to accidents from freezing because the inlet and outlet pipes are nearer the side than in larger holders, so that ice, spreading over the surface from the periphery, takes a shorter time to reach the pipes. To ensure that there is no cooling of the holder water, however long the spell of cold weather may be, the rate of steam input to the holder should be at least equivalent to the rate of heat loss from the surfaces. The following examples are based on an atmospheric temperature of 20 deg. F. and an initial holder water temperature of 42 deg. F. throughout:—

Average rate of heat loss per square foot per hour through holder wall	34	B.Th.U.
For a holder of 200 ft. diameter; tank, 30 ft. deep:—		
Heat extracted per hour	640,000	B.Th.U.
Steam required at total heat of 1,100 B.Th.U. per pound ...	580	lb.
For a holder 60 ft. in diameter; tank, 20 ft. deep:—		
Heat extracted per hour	130,000	B.Th.U.
Steam required	120	lb.

As a point of interest, the practice of the Gas Light and Coke Company has been to provide 100 lb. to 125 lb. of steam per hour per injector, and to allow one injector for a length of cup or tank water space up to 180 ft., so that for a 200-ft. diameter holder, four injectors would be provided in the tank, requiring about 500 lb. of steam per hour, and a similar quantity would be delivered to each cup; for a 60-ft. holder, one injector would be provided in the tank, requiring 125 lb. of steam per hour, and a similar quantity would be provided for each cup. The boiler pressure should be from 20 lb. to 30 lb. per square inch greater than the static head of the pipe lines to the highest position of the top-lift cup, to ensure that they cannot be logged by condensate. It is recommended that the procedure which is standard practice in countries such as Canada might be adopted with advantage in this country; that is, when the atmospheric temperature drops below freezing point, the temperature of the holder water is checked and recorded at predetermined intervals.

(To be continued.)

LABOUR NOTES.

DURING the past two or three years, the Trades Union Congress has given detailed attention to problems of native labour in British Colonies. Through the General Council's Colonial Advisory Committee, advice and assistance have been given to the new trade-union movements which have been begun in many parts of the Empire. This work has been carried on in regular collaboration with the Colonial Office, and despite the many difficulties due to the war, it is hoped to maintain the contacts which have been made to the fullest extent practicable. Certain suggestions have recently been under consideration, one of which concerned the Government Labour Officers appointed by the Colonial Office to deal with native labour questions and to advise the native unions in the Crown Colonies and Protectorates. These appointments have been made for some time on an increasing scale, and it is understood to be the Government's intention to extend the system.

The Colonial Office has suggested that some experienced trade unionists, with their intimate knowledge of the movement in this country, might give valuable help of the desired kind, and hope is expressed that the first nomination will be made as early as possible in order that the idea may be tried out without delay. Persons selected for these posts are first to undergo a few months' training at the Ministry of Labour, after which they will be attached for first-hand Colonial experience to one of the Labour Offices or Departments already functioning in a number of Colonies. Candidates should be between the ages of 28 and 40.

Mr. Luke Fawcett, president of the Amalgamated Union of Building Trade Workers since 1934, and now acting general secretary, has been elected to take the place on the General Council of the Trades Union Congress vacated by Mr. George Hicks, M.P., on his appointment as Parliamentary Secretary to the Ministry of Works and Buildings. Mr. Fawcett joined the Leeds branch of the Operative Bricklayers' Society in 1902 and, four years later, transferred to the Manchester branch of which he became president. He was chairman of the Manchester District Committee and also of the Manchester Federation of Building Trades Operatives. For 14 years he was N.W. Regional Organiser of the Amalgamated Union of Building Trade Workers. He has taken a prominent part in negotiations with employers, and is a member of several joint councils of employers and employees in the building industry.

According to the writer of the editorial notes in the December issue of *Man and Metal*, the journal of the Iron and Steel Trades Confederation, "the conferences which have been held in most of the important centres up and down the country for the purpose of emphasising the need of working after the 'Alert,' have had an excellent effect." "The attendance," he says, "at each of the conferences of a representative of the Air Council did a lot to bring into focus the utter dependence of the Forces, and particularly the R.A.F., on the man in the workshop. On the whole, we think it can be safely said that in the overwhelming majority of cases, the managements and the men are ready to co-operate to the utmost to achieve the desired results. Indeed, we have heard of instances where remarkable ingenuity has been shown in working out local signalling systems."

The National Maritime Board has agreed to increase the pay of British seamen and officers by 2*l.* a month as from January 1, in order to bring the remuneration of British crews more into line with that of other allied officers and men. There is also to be an extension of the compensation payable by owners for the loss of crew's effects by marine peril, and the Ratings Panel of the Board has decided, as a war-time measure, to increase overtime rates in port.

On Sundays and official religious holidays in Spain, all work on account of another person is prohibited. The Sunday or holiday begins at midnight, and the rest must last for at least 24 consecutive hours. It may, however, be calculated in any other way, provided its length is not affected, in cases where the special needs of particular industries do not permit of the normal calculation without grave disadvantages. The prohibition does not apply to work done by the person concerned on his own behalf as a pastime or for the improvement of his dwelling. Neither does it apply to the following:—Domestic service; authorised public entertainments; intellectual or artistic work done by the person concerned on his own account or voluntarily and without publicity; stock-breeding and the care of flocks in country districts; agricultural work connected with harvesting, sowing, transport and storage of products; irrigation and, in general, all work which cannot without serious disadvantage be performed except during short periods, and work arising out of calamities of nature; seasonal fishing; and work on board ship required for the safety, operation and essential cleanliness of the vessel. For most of these, however, other periodical rest days are prescribed.

An Order relating to the functions of foremen in heavy engineering undertakings promulgated by the Council of People's Commissaries and the Central Committee of the Communist Party of the Soviet Union, makes foremen responsible heads of the sections entrusted to them. Foremen, it is provided, must be selected from among engineers, technicians and highly-skilled workers. Persons with no technical training may not become foremen except after approval by a special committee, and foremen are to be appointed and discharged by the heads of undertakings on the proposal of the heads of the shops concerned. The foreman is placed under the direct orders of the head of the shop and the instructions of the management are transmitted to the workers through him. He may impose penalties for breaches of labour discipline and, with the approval of the head of the shop, he has the right to engage and discharge workers. He also has the right to dispose of the wage fund allotted for the execution of the production programme and to grant bonuses to workers of special merit.

For the last-named purpose, he may avail himself of a bonus fund amounting to not more than 2 per cent. of the wage fund for the workers under his orders, but the bonus fund is not to be utilised when the wage fund is exhausted. Among the duties of foremen mentioned in the Order are:—An obligation to revise standards of output, the allotment of a fixed place for each worker, the giving of necessary instructions to workers, supervision of the handing over to workers of tools, raw materials and other requirements, and supervision of the observance by workers of technical and safety rules, etc. Foremen, it is decreed, must also encourage the employment and development of Stakhanovist methods of production and assist young workers.

The wages of foremen employed in heavy engineering undertakings were increased as from June 1 last to a level which made them higher than the average wage of skilled workers. The monthly wage was fixed at a maximum of 950 to 1,100 roubles and a minimum of 500 to 550 roubles. Foremen are also entitled to the following:—A bonus for production in excess of the monthly programme, amounting to from 3 to 5 per cent. of the wage for every 1 per cent. of production in excess of the programme; and a bonus for savings on the wage fund, provided that the monthly programme of production is carried on in full, this bonus amounting to from 25 to 50 per cent. of the amount of the savings in question. The head of the shop may withhold from the foreman all or part of his bonus in the event of infringement of the provisions regulating the utilisation of materials, fuel and the wage funds.

The National Arbitration Tribunal is to hear the claim of the Amalgamated Engineering Union and the National Union of Foundry Workers for an increase of wages on January 7 and 8, and that of the Joint Trades Movement on January 16. The Amalgamated Engineering Union and the National Union of Foundry Workers desire an advance of 3*d.* an hour on base rates and restoration of certain conditions existing prior to June, 1931. The other unions have asked for an advance of 10*s.* a week.

A recent circular letter issued by the Ministry of Supply, and addressed to all branches of the machine-tool industry, states that another 15,000 operatives are required as soon as possible, a requirement which involves the training and employment of three more operatives for every ten now at work. It is admitted that there are difficulties in utilising women in this highly-skilled industry, but it is urged, in view of the urgent calls upon manpower in the national effort, that their recruitment should be seriously considered. It is further stated that the output of the machine-tool industry in the United States will be increased by September, 1941, to three and a half times the output of the year before the outbreak of war. This expansion, while encouraging and satisfactory, does not, of course, relieve the necessity for continued increase in the British output.

THE PHYSICS OF STEAM GENERATION.*

By R. F. DAVIS, M.Sc. (Eng.).

IN general, boiler water is a dilute aqueous solution of dissolved salts, together with matter in suspension and traces of dissolved gases. As evaporation proceeds, the boiler water becomes more concentrated, and precipitation occurs. Each salt has its own peculiar solubility characteristics, its precipitation point depending on temperature, concentration, and the quantity and nature of the accompanying salts. The dissolved salts consist mainly of the sodium salts: sodium sulphate, sodium chloride, and sodium hydroxide. The first, sodium sulphate, may occur up to 75 per cent., and the other two salts in amounts up to 50 per cent. of the total dissolved solids.

In high-pressure and central station plants, the amount of dissolved solids is usually kept well below 3,000 parts per million, but in low-pressure industrial plants the concentration may be allowed to rise to nearly 10,000 parts per million. It has been recommended (Glinn 1935) that 7,000 parts per million is the limit of good practice up to 600 lb. per square inch, and 1,500 parts per million above 850 lb. per square inch up to 1,500 lb. per square inch. The effect of the dissolved salts on the surface tension depends on the degree of adsorption, the surface tension of pure water in contact with its vapour being 71·4 dynes per centimetre at 15 deg. C. (Kaye and Laby, 1935). As it is only 71·7 dynes per centimetre for the extremely high concentration value of 10,000 parts per million, this is of interest as demonstrating that the surface tension is not greatly affected by the concentrations met with in practice, the difference between the two figures being less than 0·5 per cent. There is, however, considerable variation in the surface tension, depending on the saturation densities of the water and the steam.

Steam Generation.—Evaporation from a submerged heated surface may take place either by nuclear boiling, or by film boiling. In nuclear boiling, the water evaporates into steam bubble spaces and is superheated because the surface tension at the bubble interface raises the internal pressure. Theoretically, nuclear boiling cannot originate at an absolutely plane surface, where the initial diameter of a bubble would be infinitely small and the superheating of the water infinitely high, but in a boiler the metallic surface in contact with the water has free binding forces, which may build up small solid particles and gases into layers of from 10 to 20 molecules in thickness. A surface indentation or scratch will accordingly be associated with a highly concentrated mass of adherent particles, and form a nucleus for evaporation if the metal is heated above the boiling point of the liquid (Schmaltz, 1937). Surface irregularities and roughness due to oxide and scale deposits can similarly become points of nuclear generation.

In nuclear boiling the slight superheating of the water provides the impulse for heat transfer from the water to the steam, the amount of superheating varying with the pressure. Moreover, the amount of superheating decreases with increasing pressure because the surface tension decreases. In close proximity to the heating surface, the temperature of the water approaches the temperature of the surface itself. In nuclear boiling the heat transfer takes place, first, from the heating surface to the boiling liquid and, second, from the liquid to the surface of the bubbles, from which, the liquid evaporates into the bubble (Bosnjakovic, 1930). Since bubbles originate in the more highly superheated layer adjacent to the heating surface, they are subjected to a higher temperature in the earlier period of their development than in the later stages. According to Jakob the coefficient of heat transfer across the bubble surface at the moment of origin of the bubble is of the order of 40,000 B.Th.U. per square foot per hour per deg. F. temperature difference, but this is only momentary, and decreases rapidly as the bubble grows in size. When the bubble has detached itself from the heating surface and so left the highly superheated layer, the transmission rate across its surface tends to assume a steady value of about 3,000 B.Th.U. per square foot per hour per deg. F.

The temperature difference between the heating surface and the water as a whole is affected to a certain extent by the convection or stirring effect of the rising bubbles and, therefore, by the number of nuclei per unit area of heating surface and by the frequency with which bubbles form at a given nucleus. Jakob found the coefficient of heat transfer between a heated metal plate and water to vary, not only with the intensity of heating, but also with the condition of the surface, that is, its roughness and whether it had been previously exposed to the atmosphere and had adsorbed air on its

* Paper entitled "The Physical Aspect of Steam Generation at High Pressures and the Problem of Steam Contamination," read before the Institution of Mechanical Engineers, on Friday, December 13, 1940. Abridged.

surface, also with the length of time it had been in service. Once a state of nuclear boiling has been attained at a given place, the steady application of heat at that place results in a uniform rate of bubble formation there, but an increase in the rate of heating gives rise to fresh nuclei because the higher superheating of the water in contact with the heating surface allows vapour bubbles to originate at places of smaller curvature. This process does not, however, continue indefinitely, for, with an increasing rate of heating, a state is eventually attained in which the bubbles become so numerous and closely packed that they coalesce and so form a continuous film of vapour between the heating surface and the liquid. Then evaporation takes place by film boiling, when the vapour leaves the film in the form of large irregular-shaped bubbles.

The change from nuclear to film boiling is well illustrated in a paper by Drew and Mueller, in which also reference is made to the curve for water derived by Nukiyama (1934), which shows the quantitative effect of a progressive increase in the rate of heating. At one point in the curve of heat flow, i.e., after the limit of nuclear boiling has been passed, a sharp change occurs of a kind such that further increase in the heat flow will actually lead to a decrease in the transmission

Fig. 1.

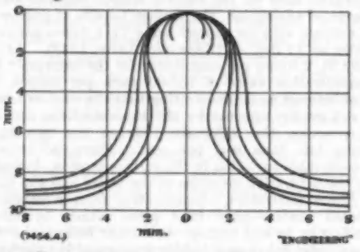
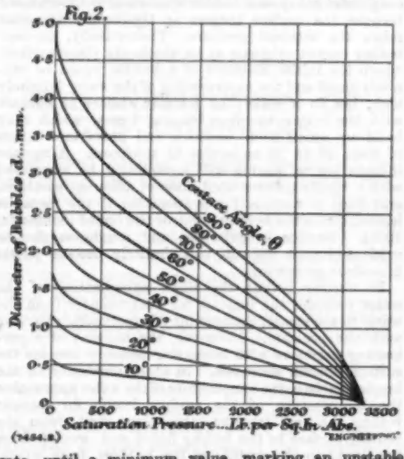


Fig. 2.



rate, until a minimum value, marking an unstable state in which parts of the vapour film collapse in an irregular manner, is reached. Any increase in the rate of heating beyond this value will cause a gradual increase in the transmission rate, but only at the expense of a considerable increase in the metal temperature, because the heat will then be transferred across a continuous film of vapour having a relatively low conductivity. There is much evidence supporting the view that the maximum rate is influenced considerably by the nature and condition of the heating surface. For instance, Jakob obtained heat flow rates as high as 95,500 B.Th.U. per square foot per hour from a flat horizontal copper plate, and at this rating nuclear boiling still persisted. Again, with a vertical cylindrical heating surface of the same material, he found that above 74,000 B.Th.U. per square foot per hour the transmission rate from the heating surface to the water decreased with a rapid rise in the metal temperature, which eventually burnt out the electric heating elements. The latter rating for a vertical surface corresponds to the heat flow which results in a boiler tube when subjected to the radiation from a luminous flame at a temperature of about 2,300 deg. F.

That the condition of the heating surface has considerable influence on the critical rating at which the change from nuclear to film boiling occurs, has also been demonstrated by Rhodes and Bridges (1938), who found that the wettability of the surface, or more accurately the contact angle between the liquid and the heating surface, has a profound effect on the rating. Relatively small amounts of certain substances in solution or in suspension may also have a great effect in altering the manner of boiling. Evidently the critical rating for a boiler tube or plate will depend on the nature of the boiler water, on the condition of the effective heating surface, and, possibly, on the inclination of the surface. Normally evaporation in a water-tube boiler takes place by nuclear boiling, since film boiling would obviously involve such high metal temperatures that the tubes would quickly fail by rapid creep or plastic flow of the metal, especially with the high saturation temperatures which accompany high pressures. In most cases where tube failures have been reported as due to flame impingement, it is possible that either scale or choking of the tubes by sludge deposit has been a contributory cause, but the possibility of overheating of the metal under conditions of film boiling cannot be ruled out entirely until more is known about the subject.

Investigations recently carried out in America by Partridge and Hall (1939) have disclosed a phenomenon analogous to film boiling. This "steam blanketing" has, in the main, been found to occur in the case of boilers operating above 1,200 lb. per square inch and having tubes that are insufficiently inclined to the horizontal. At high rates of heat input, the bubbles collecting at the crown of these nearly flat tubes form

Fig. 3.

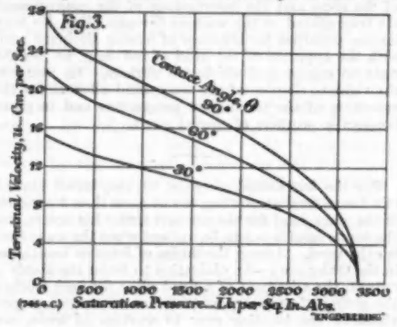
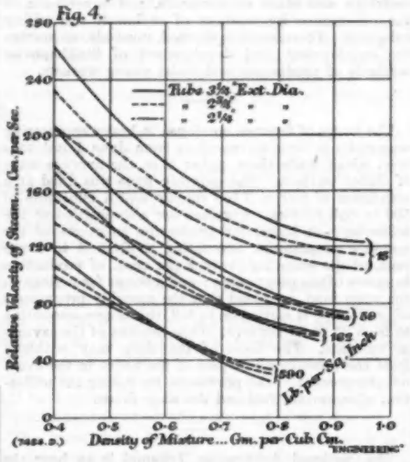


Fig. 4.


Relative Velocity of Steam ... Cm. per Sec.
Tubes 3½" Ext. Dia.
" 2¾" " "
" 2¼" " "
85
50
102 Lb. per Sq. Inch
500
0·4 0·5 0·6 0·7 0·8 0·9 1·0
(7454.D.) Density of Mixture ... Gm. per Cub Cm.
"ENGINEERING"

an almost continuous insulating steam blanket. The consequent overheating of the metal at the crown of the tube and its intermittent splashing by the relatively colder water resulted in some instances in cracking of the metal, and in others the localised concentration of the boiler water caused erosion. A state of bubble-stagnation at the crown of slightly inclined tubes is usually prevented by the circulation of the water. In the majority of the cases mentioned by Partridge and Hall failure occurred in very flat ash or slag screen tubes and the tubes supporting slagging furnace bottoms. One of the conclusions to be drawn from their investigations is that the tubes of high-pressure boilers exposed to high gas temperatures should have an inclination of at least 12½ deg. with the horizontal.

The initial size of a steam bubble depends on the radius of curvature of its original nucleus, i.e., a minute gas bubble, a particle of sludge or scale adhering to the surface, or a mere roughness on the heating surface. If this nucleus is a solid spherical surface, it cannot become available for growth until the vapour pressure at that point exceeds the equilibrium state. Surfaces with larger radii of curvature do not become nuclei, because they do not provide the same degree of concentration of vapour molecules per unit of projected area within the same period of time. If the initial nucleus is a small gas bubble, the conditions will be modified by the partial pressure within the bubble. Table I has been calculated to show the minimum radii of gas bubbles and solid surfaces which become available at different degrees of water superheating under atmospheric conditions.

With nuclear boiling the heating surface is not likely to exceed the temperature of the bulk of the water by

TABLE I.—*Minimum Radii of Gas Bubbles and Solid Surfaces.*

Superheat of Water. Deg. F.	Radius of Gas Bubble. Microns.	Radius of Solid Surface. Microns.
2	23	35
4	11	17
10	4·3	6·5
20	2·0	3·0
30	1·2	1·8
40	0·8	1·2

more than about 40 deg. F., under atmospheric conditions, and the superheating of the water layer in contact with the heating surface must be less than that figure. At this superheat, the dimensions of the

Fig. 5.

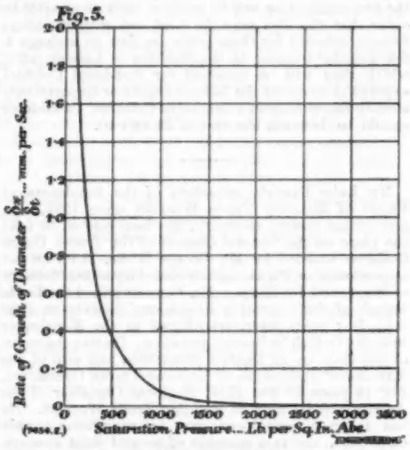
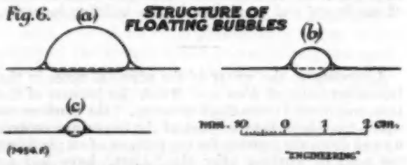

Rate of Growth of Diameter dd/dt ... mm. per Sec.
0 500 1000 1500 2000 2500 3000 3500
(7454.E.) Saturation Pressure ... Lb per Sq. In. Abs.
"ENGINEERING"

Fig. 6. STRUCTURE OF FLOATING BUBBLES



available nuclei approach those of particles which form permanent suspensions. This gives some idea of the extreme smallness of the nuclei. At higher pressures, due to the decrease in surface tension, still smaller nuclei become available. Nuclear boiling, therefore, continues to exist at high pressures and with reduction in the degree of superheat.

The subsequent shape of the bubble, as it grows in size by evaporation from its surface, is determined by the forces acting upon it. When the heating surface is horizontal and faces upwards, the bubble is symmetrical about its vertical axis, and its shape and size are calculable from considerations of static equilibrium. Although the angle of contact of the base of the bubble with the surface has no influence on the shape of the bubble above the surface, it nevertheless determines the maximum volume above which the bubble becomes unstable and breaks away, under conditions in which the buoyancy exceeds the surface tension at the circle of contact with the heating surface. To illustrate this point the profiles of stationary air bubbles in water are reproduced in Fig. 1 (Wark, 1933) for different initial radii of curvature. These are mostly shown for the limiting value of θ (the base angle) = 180 deg.; for lesser values of the contact angle a separate horizontal line must be drawn through each profile, so that each profile meets each line at the correct contact angle.

To determine the shape of a bubble and its maximum volume requires special methods of analysis, which Jakob and his co-workers, following the method of Wark, have reduced to a simple curve. This curve has been checked by Jakob for water over the range of contact angles θ from 20 deg. to 100 deg. by measuring the photographs of bubbles in the process of formation (Fig. 7). Considering that the real problem is dynamical and not statical, as assumed in the theoretical analysis, the agreement is remarkably

close. The chart shown in Fig. 2 has been prepared to show the mean diameter of steam bubbles released from a horizontal heating surface over the complete range of the saturation pressure of steam, and for contact angles from zero to 90 deg. The contact angle only equals or exceeds 90 deg. with a very smooth or a greasy surface. In the case of contact angles greater than 90 deg., the bubbles are liable to take up a re-entrant shape, and break away at the narrowest section of the neck, where it is nearly cylindrical, and the volume of the released portion is the same as if the contact angle were 90 deg. Bubbles of a re-entrant shape have a considerable area of contact with the heating surface, thereby causing a rise in temperature of the surface. They also tend to join up with neighbouring bubbles and form a continuous film more easily than when the contact angle is less than 90 deg. Hence, at a greasy surface the change from nuclear to film boiling occurs at a much lower rate of heat flow, as found by Rhodes and Bridges. The contact angle measured under atmospheric conditions may not correspond to that existing during evaporation. The only satisfactory method would be to photograph steam bubbles in the process of formation; so far this has not been recorded for boiler water in contact with steel that has been in service, but provisionally it may be assumed that in a boiler the contact angle is about 45 deg.

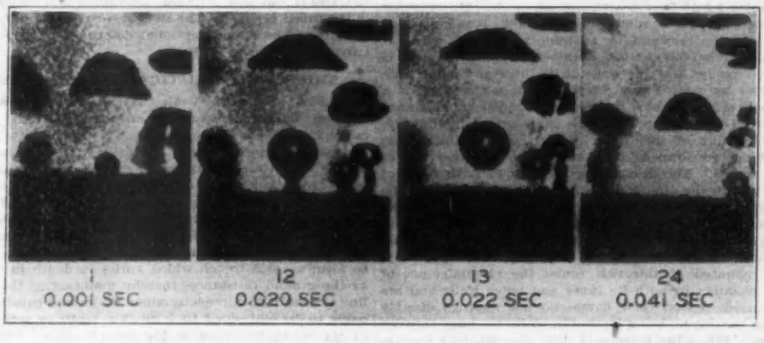


FIG. 7. BUBBLE FORMATION AT A HEATED SURFACE.

In the case of a horizontal heating surface facing upwards, the size of the steam bubbles at release is calculable, within limits, and varies with the boiler pressure and, to some extent, with the nature of the boiler water and the condition of the heating surface. In practice, heating surfaces have non-uniform inclinations, and the size of bubbles at release, though observable, is not amenable to mathematical treatment. For a heating surface facing upwards, however, the size of the bubbles released does not change to any appreciable extent between the limits of the horizontal and vertical positions of the surface, but when the surface is facing downwards the results are different; the more nearly horizontal the surface is, the larger the bubbles become before being released, and they tend to flatten out against it, causing, in the extreme case, steam blanketing and possible overheating of the metal. In the tubes of a water-tube boiler the bubbles are subjected, in addition to their buoyancy, to a transverse shearing force imparted by the flow of the water along the tube. Bubbles are thus torn off the heating surface more quickly and are therefore smaller in size than if detached by the action of buoyancy alone. In a water-tube boiler, therefore, at release from the heating surface some bubbles will be larger and some will be smaller than indicated by Fig. 2, depending on the velocity of circulation in each tube, and the slope and aspect of each individual portion of the heating surface.

At the instant of release of each bubble from its circle of contact with the heating surface (Fig. 7), the narrow cylindrical neck which forms between the base of the bubble and the heating surface, rapidly elongates and closes in, with an impact, causing a sound wave. The characteristic noise associated with ebullition is produced by a succession of these minute impacts, which occur with a momentum that largely depends on the viscosity of the liquid. At higher saturation pressures the viscosity of water diminishes (Sigwart, 1936), and, therefore, the suddenness with which bubbles are released increases. The frequency of release from a given nucleus will also increase with the saturation pressure and, according to Jakob's experiments, will be inversely proportional to the bubble diameter. Immediately a bubble is released, it will commence to rise on account of its buoyancy, at an increasing speed, and the downward pull of the surface tension, which previously anchored it to the heating surface, will be replaced by a pressure on the upper surface. In this case the bubble will flatten out to a lens shape (Fig. 7). In sufficiently deep liquid, the bubble will gradually attain its terminal velocity and approximate to a spherical shape. Generally the conditions in a boiler are such that the motion of the bubbles through the liquid is turbulent.

Fig. 3 shows the calculated terminal velocities for bubbles leaving horizontal heating surfaces with contact angles of 30 deg., 60 deg. and 90 deg., and having mean diameters according to Fig. 2. The equation for the terminal velocity of the bubble is based on the assumption of a single bubble moving in an extensive field of liquid, and Jakob records a mean velocity of 26 cm. per second for bubbles from 1 mm. to 8 mm. in diameter; this agrees fairly well with the equation, which, for the same range of sizes, gives a mean velocity of 24 cm. per second. On the other hand, Behringer (1934) found that when the bubbles are closely packed in a tube, they rise at considerably greater velocities, as indicated by the curves in Fig. 4, which are reproduced from his experimental results. Behringer's results merit close consideration, because in a water-tube boiler the size and relative velocity of the bubbles control the circulation, and, to some extent, the quality of the steam. Behringer explains the increase in the relative velocity of the steam and water with increase in the proportion of steam, as due to the mass-effect of the closely packed bubbles and the entrained liquid. Yet an exactly opposite phenomenon occurs with a cloud of solid particles moving through a liquid, the rate of sedimentation of solid particles decreasing with increase in the concentration. It is strange, therefore, that bubbles seemingly behave in a contrary manner; the more concentrated they are, the faster they move.

The tube which Behringer used was totally enclosed. Brooks and Badger (1937), experimenting with a long glass tube heated throughout its length, observed that the bubbles coalesced, pushing ahead of them slugs of liquid, which subsequently became thinner by evaporation and finally broke, allowing the vapour to pass through them. Annular rings of liquid then appeared, and spread over the walls, in the form of an irregular film. Although the tube used by Behringer was not heated throughout its length, as in Brooks and Badger's experiments, it is probable that some of the bubbles, in passing up the tube, coalesced with others. Presumably Behringer, and also Brooks and Badger, used in their experiments pure water, or water containing only a very small proportion of dissolved salts. The bubbles in pure or nearly pure water will easily coalesce, and because of this, pure water will neither aerate nor foam. It is extremely likely, then, that coalescence did occur in Behringer's steel tube, as was observed in Brooks and Badger's glass tube.

In a boiler, coalescence of the steam bubbles is not so likely to occur. Under certain conditions boiler water will form a stable foam, and this property may be attributed to the influence of either suspended solids or colloidal matter; but a liquid can aerate, or possess the property of "foamability," without necessarily forming a stable foam. Dissolved salts alone can impart to water the property of aeration, or foaming in such a manner as to prevent coalescence of bubbles below the water level. Edser (1922) explains the stabilising action of dissolved salts on bubbles in terms of molecular attraction. In a pure liquid, when two bubbles approach one another the liquid will tend to be sucked out from between them and they coalesce. When, however, there is a definite increase or decrease in surface tension with change in concentration (positive or negative adsorption), the concentration in the space between the bubbles will differ from that of the bulk of the liquid, with the result that the osmotic pressure becomes unbalanced, and the unbalanced force will tend to stop the motion of the bubbles. Foulk (1937) has put forward a somewhat similar theory, and pointed out that the bringing together of positively and negatively adsorbed substances in solution in the correct proportions destroys the foam forming properties of both.

The concentrations at which soluble salts begin to stabilise steam bubbles may be indicated by their threshold carry-over values. Foulk found these to be 4,235 parts per million for sodium chloride, 3,946 parts per million for sodium carbonate, and 3,151 parts per million for sodium hydroxide. These values apply only to the particular conditions of the tests, the effect of pressure and other factors being unknown. The stabilising effect of salts having the same kind of adsorption is additive. Compared with the carry-over limits found by Foulk, Vorkauf (1931) gives 10,000 parts per million as the commencement of foamability of sodium-chloride solutions, but for other salts he finds the foamability concentrations are about the same as the carry-over concentrations of Foulk. Although the foregoing foamability concentrations have been observed at atmospheric pressure, they are mostly within the region of the total concentrations existing in low-pressure boiler plants. At higher pressures Vorkauf found that the carry-over limit occurred at progressively lower rates of evaporation; it is probable that the foamability concentration is reduced by increasing the saturation pressure; hence the lower concentrations carried in high-pressure boilers do not preclude the possibility of the non-coalescence of the steam bubbles, or foamability.

The question of foaming is mentioned here to emphasise the need for caution in applying the results of experiments with pure or nearly pure water, to the conditions which exist in a boiler. It is probable that in a boiler the steam bubbles do not coalesce so readily as in the experiments of Brooks and Badger, and Behringer. We must consider, then, what happens to a bubble that does not coalesce with others in its passage from the heating surface to the free water level. Such a bubble, after leaving the heating surface, will continue to increase in size; first, by expansion of the vapour due to consequent reduction in the static head, and, second, by growth due to evaporation from the bubble surface. The expansion of a bubble on account of reduction in pressure can be assumed to take place isothermally, according to Boyle's Law. At atmospheric pressure the increase in volume is about 30 per cent. for each 10-ft. difference in level below the free water surface, but in a boiler operating at 400 lb. per square inch pressure the increase in volume is less than 1 per cent. for the same change in level. It is evident that in a high-pressure boiler the size of the steam bubbles will not alter appreciably on account of changes in level, even though they originate 30 ft. or 40 ft. below the water level, because the relative decrease in total pressure will only be slight.

Each bubble after it leaves the highly superheated layer of liquid in contact with the heating surface, will continue to increase in size by evaporation from its liquid-vapour interface, but at a considerably reduced rate. Jakob and his co-workers found that the coefficient of heat transfer across the bubble surface was fairly uniform throughout the bulk of the water, with a mean value of about 3,200 B.Th.U. per square foot per hour per deg. F. Assuming that the pressure remains sensibly uniform during growth, the rate of growth of a steam bubble is independent of its size. Therefore, at the same saturation pressure, both large and small bubbles will increase in diameter at the same rate. Confirmation of this theory is provided by Jakob's tabulated observations of the rate of growth, under atmospheric conditions, of six steam bubbles, the initial sizes of which varied from 0·5 cub. mm. to 83·5 cub. mm., and showed an almost constant average rate of growth of diameter of 15·5 mm. per second.

There does not seem to be any reason why the coefficient of heat transfer (3,200 B.Th.U. per square foot per hour per deg. F.) found by Jakob for the bulk of the water should vary with the pressure; and on the assumption that it is constant for all pressures the curve in Fig. 5 has been constructed. It will be noted that at atmospheric pressure the rate of growth is enormous compared with that at boiler operating pressures, but agrees substantially with the value 15·5 mm. per second deduced from Jakob's observations. Taking the initial bubble size as that obtained from Fig. 2 for 45 deg. contact angle, it is equivalent to an increase in diameter of 650 per cent. in the first second after release from the heating surface. On the same basis, at 250 lb. per square inch pressure, the increase in bubble diameter in the first second is only 50 per cent.; and at 1,000 lb. per square inch the increase is only 5 per cent. At higher pressures the rate of growth is almost insignificant, since the time taken by the bubbles to migrate from the heating surface to the free water level, even in a large water-tube boiler, is only a matter of two or three seconds. The actual time taken in migration depends not only on the relative speed of the bubbles with respect to

the water, but also on the velocity of circulation of the water in the tubes and the distance traversed. The circulation in high-pressure boilers has already been dealt with elsewhere (Davis and Timmins, 1933), but it is evident that no great error will be introduced into circulation calculations at high pressures by neglecting the velocity of the bubbles relative to the water (Fig. 3, page 18), in view of the fact that no appreciable increase in the size of the bubbles will occur after they leave the heating surface unless the boiler water is so pure that considerable coalescence takes place.

Bubbles arrive at the free water level in a boiler, partly by the action of convection currents set up by circulation, and partly by the velocity imparted by their own buoyancy. Each bubble as it arrives just below the water level pushes up the surface into a hummock, which instantly drains away on all sides to form a nearly complete hemispherical, dome-shaped lamina of liquid. Even in pure water the bubbles do not push straight through the surface and burst immediately on arrival, but remain floating at the surface for a fraction of a second; if salts or other stabilising agents are present, the bubbles may continue to float at the surface for even longer periods before they burst. The excess pressure inside these evanescent floating bubbles depends on the size of the dome.

Large bubbles, say, greater than 2 cm. in diameter, have a practically horizontal interior water surface, which is only very slightly depressed below the exterior water level, as indicated in Fig. 6*a*; but in smaller bubbles the excess pressure is greater for the same surface tension, and at about 1 cm. diameter the interior surface is appreciably curved as in Fig. 6*b*. In still smaller bubbles, say, less than 0·5 cm. in diameter, the water surface becomes nearly hemispherical, as in Fig. 6*c*, but its radius is, of course, only half that of the dome. These observations apply to water under atmospheric conditions. In the bubble dome, the surface tension at the inner surface of the film only balances half the excess pressure, the remainder being transmitted through the liquid in the film to the outer surface. There is thus a squeezing action between the two surfaces, tending to thin the film. This force, assisted by gravity, causes the ultimate failure of the film by thinning at the top of the dome.

(To be continued.)

CATALOGUES.

Disconnecting Boxes.—Messrs. British Insulated Cables, Limited, Prescot, Lancashire, have sent us a folder explaining the features of their detachable pocket-type disconnecting network boxes and illustrating their various adaptations.

Gas Heating.—Messrs. Controlled Heat and Air, Limited, 16, Grosvenor-place, London, S.W.1, have sent us a circular dealing with their system of space heating by gas firing. Standard units with capacities varying from 80,000 to 900,000 B.Th.U. per hour can be supplied, and a table of ratings is included in the folder.

Winches.—Messrs. John M. Henderson and Company, Limited, King's Works, Aberdeen, have sent us a catalogue illustrating their various types of electrically-driven winches for use in aerial cableways, dragline excavators and scrapers, and for operating slipways. Illustrations are given of winches supplied to various parts of the world for handling coal and other materials.

Recording Thermometers.—We have received from Messrs. Budenberg Gauge Company, Limited, Broadheath, near Manchester, a leaflet containing particulars of their "Dunham" and "Timperley" recording thermometers. These instruments are of the mercury-in-steel type, are fully compensated for variations in case temperature, and are adapted for surface or flush mounting.

Switchgear.—Messrs. A. Reyrolle and Company, Limited, Hebburn-on-Tyne, have sent us a pamphlet describing their flameproof air-break switchgear, which has been developed to meet the requirements of those industries in which there exists a risk of explosion. The units, in addition to being flameproof, enable isolation and maintenance to be effected without shutting down other sections of the electrical system.

CHART OF IRON AND STEEL PRICES.—Messrs. W. Richards and Sons, Limited, Britannia Foundry, Middlesbrough, have sent us a copy of the 21st annual edition of their wall chart of prices of iron and steel products. The variations in the prices, at intervals during the years 1914 to December, 1940, of bar iron (Crown quality), iron castings, iron ship rivets, steel ship plates, steel angles, steel rails and pig iron (Cleveland No. 3 quality), are given in graphical form and in contrasting colours. Spaces for the year 1941 have been left blank, so that the graphs may be continued and the chart kept up to date.

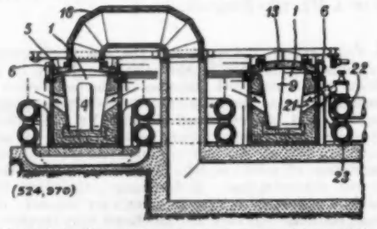
"ENGINEERING" ILLUSTRATED PATENT RECORD.

ABSTRACTS OF SPECIFICATIONS RECENTLY PUBLISHED UNDER THE ACTS OF 1907 TO 1939.

The number of views given in the Specification drawings is stated in each case; where none is mentioned, the Specification is not illustrated.
Where inventions are communicated from abroad, the Names, etc., of the Communicators are given in italics.
Copies of Specifications may be obtained at the Patent Office Sales Branch, 25, Southampton Buildings, Chancery-lane, London, W.C.2, price 1s. each.
The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.
Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

FURNACE APPARATUS.

524,970. Ingot-Heating Furnace. The Wellman Smith Owen Engineering Corporation, Limited, of London, and B. H. Schieldrop, of London. (4 *Figs.*) February 14, 1939.—The furnace is for the heat treatment of steel ingots prior to rolling, and is of the so-called "continuous" type. The furnace consists of an annular chamber 1 with fixed hearth and side walls. The chamber is deep enough to allow the ingots 4 to stand upright, and the top is closed by an annular cover 5, which is rotated relatively to the chamber on rollers 6 and is sealed against the side walls at its inner and outer peripheries by sand seals. Suspended from the cover is a radial wall 9, which leaves only sufficient clearance between its edges and the walls and hearth to permit the free turning of the cover. Charging and discharging openings are formed in the cover, one on either side of the wall 9. The discharging opening 13 is in front of the wall in the direction of rotation of the cover and the charging opening is behind it. Behind and near the latter is an exit for the products of combustion connected to a chimney by a radial conduit 16. Burners 21 supplied by annular gas and hot air mains 22, 23, respectively, are mounted at intervals round the circumference of the chamber in both its inner and outer walls and are arranged so that their flames do not impinge directly upon the ingots, being located opposite the gaps between them. When the furnace is fully charged, four burners



in the outer wall and three in the inner wall immediately in front of the suspended wall 9 are turned on, the rest being left inoperative. This produces a hot end in front of the wall 9 and the products of combustion travel round the annular chamber 1 towards the cold end, where the gas exit is situated. When the first of the ingots 4 in front of the suspended wall has been sufficiently heated, the lid 13 of the discharging opening, which is immediately above the ingot, is opened and the ingot is withdrawn by an ingot-charger. After this ingot has been removed and the lid 13 closed, the cover is turned bodily through the interval at which the ingots are spaced, bringing the charging opening over an empty position on the hearth. The lid is then opened and a cold ingot is placed upon the hearth. The whole cycle of operations is then repeated indefinitely, the cover being advanced step by step relatively to the ingots on the hearth. As the cover is rotated step by step, any burner which comes behind the suspended wall 9 is turned off and an inoperative burner forward of the wall turned on. The hot and cold ends thus progress round the furnace chamber, the heated piece being always removed from what has last been the hot end, while the cold piece is introduced into what has recently become the cold end. (*Accepted August* 19, 1940.)

MINING, METALLURGY, ETC.

518,212. Steel Manufacture. Stewarts and Lloyds, Limited, of Glasgow, and H. A. Dickie, of Kettering. June 10, 1938.—This invention is a two-stage basic Bessemer process which provides a high quality product without undue loss of iron or decrease in yield. Iron containing about 0·38 per cent. silicon, 0·135 per cent. sulphur, 2·06 per cent. phosphorus, 0·38 per cent. manganese, and 3·5 per cent. carbon is first blown as in normal practice, using the normal amount of lime, but only about 60 lb. instead of the usual 100 lb. of cold scrap per ton for this class of iron. More heat is kept in the metal by using less cold scrap additions. The blowing is continued until the phosphorus content is reduced to the usual value, for normal steel, of 0·03 per cent. to 0·08 per cent. The slag from this stage is removed as completely as possible, and constituents for the formation of a second slag are added to the converter. For a 25-ton converter, 1,500 lb. of lime and 100 lb. of sand are added. A second blowing is given for 10 seconds to 30 seconds, the period being varied according to the estimated phosphorus content at the end of the normal blowing. Any extension of this blowing period which would lead to loss of iron or any considerable formation of oxide is avoided. The sulphur is kept at a low value by using iron treated to give low sulphur. The phosphorus content is reduced in this stage to about 0·016 per cent. to 0·017 per cent., and the sulphur content to about 0·03 per cent. After completion of this stage, either the second slag is kept back in the converter, while the metal is poured into the ladle, deoxidisers or alloys being added to the ladle, or the second slag is removed as completely as possible, and deoxidisers or alloys are added to the metal in the furnace before pouring. This permits a gaseous reaction to be brought about in the metal by means of carbon-containing additions alone or combined with oxide or scale. The process results in a product of high purity, in which the carbon and phosphorus contents are unusually low. Since these are segregating elements, the steel is rendered free from banding or non-uniformity in the rolled product. The steel also has a high ductility and toughness and exceptional deformation properties. (*Accepted February* 21, 1940.)

SHIPS AND NAUTICAL APPLIANCES.

524,823. Submarine-Cable Trench Plough. British Western Union, Limited, of London. (6 *Figs.*) February 8, 1939.—The plough forms a trench in the sea bed and simultaneously places the cable C in the trench. At the same time, a transmitter mounted on the plough sends indications to the cable ship of the depth of trench being formed. The plough is towed by a towline T, and consists of two platform frame members D and E, connected together by forward and after link arms 18, which cause a ploughshare 20 secured to the platform D to form a cable trench which varies in depth inversely as the ground resistance, thereby maintaining the towline tension within predetermined limits and causing the cable to be embedded to a greater depth in soft areas of the ocean bed than in the denser areas. Skids 22 enable the plough to slide along on the sea bed. The

Fig. 1.

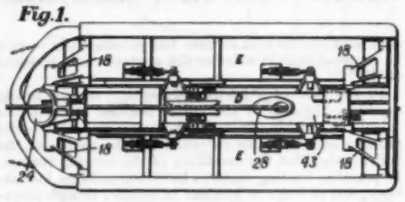
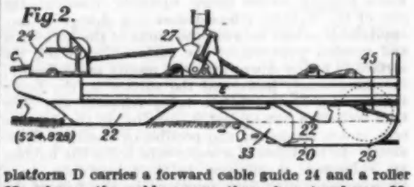


Fig. 2.



platform D carries a forward cable guide 24 and a roller 27, whence the cable passes through a trunkway 28, and is forcibly laid in the bottom of the trench by a guide roller 29, between two side plates, which prevent material displaced by the plough from sliding or being washed back into the trench before the cable is laid in it. The platform D in its lowest position rests on the platform E, and tension springs oppose their separation. When the ground resistance builds up, a couple is created with the towing tension, tending to separate the two platforms D and E vertically. Thus the platform D rises to different heights depending upon the density of the material forming the bed. To prevent fouling of the ploughshare 20 by obstructions in the sea bed, a web 33 extends between the ploughshare and the platform D, the inclined forward edge of which engages any obstruction and causes the ploughshare to be lifted up over the obstruction. On the plate 43 of the platform D is mounted a transmitter to show on board ship the depth of the cable trench being formed. Signals are transmitted through a signal cable to the ship, where a receiver indicates and records the depth of the trench at any instant. The transmitter consists of an oil-filled casing in which are mounted rheostat resistances. A bellows arrangement equalises the internal oil pressure with the external water pressure. The rheostat contact arms are moved by a pendulum 45, which trails over the sea bed beside the trench, its angle with the vertical affording a measure of the depth of the trench. (*Accepted August* 15, 1940.)